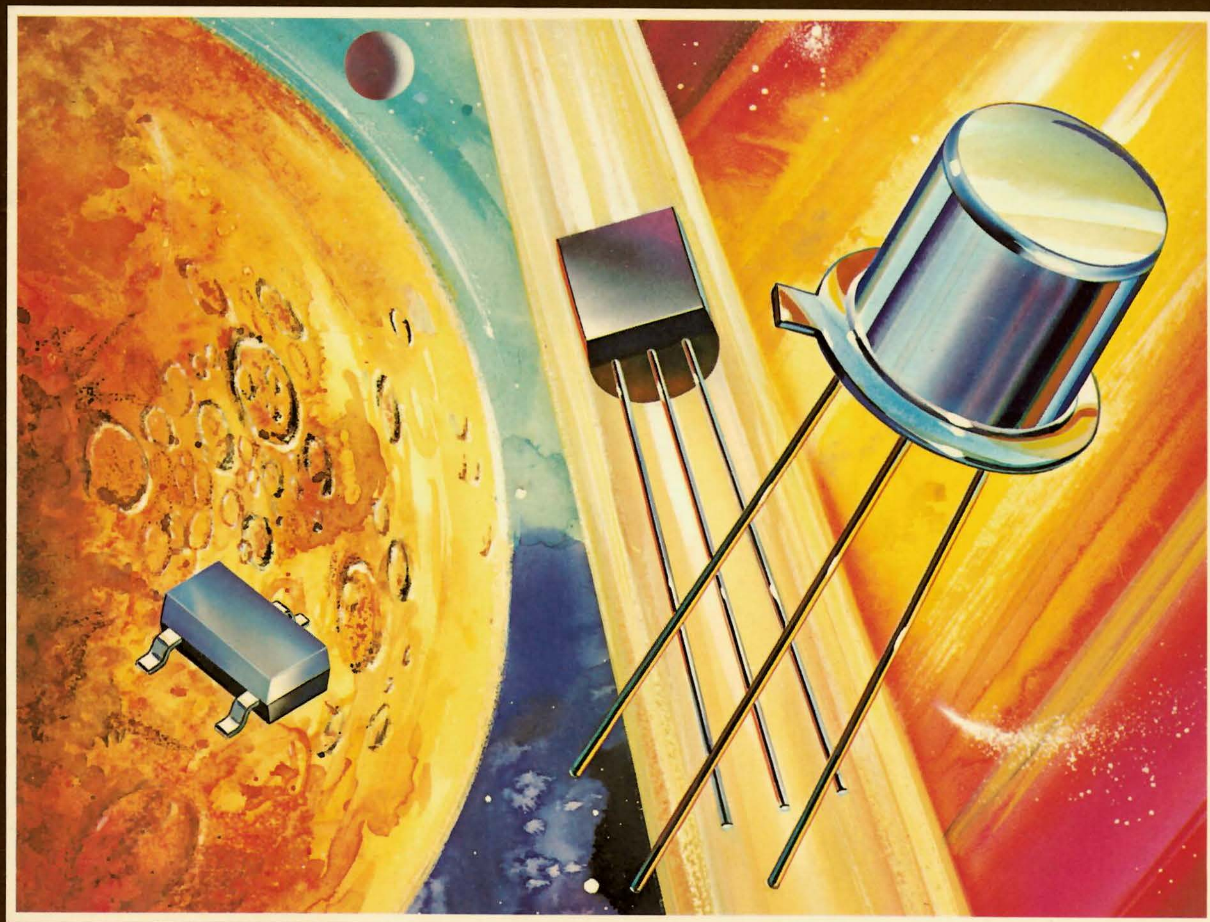
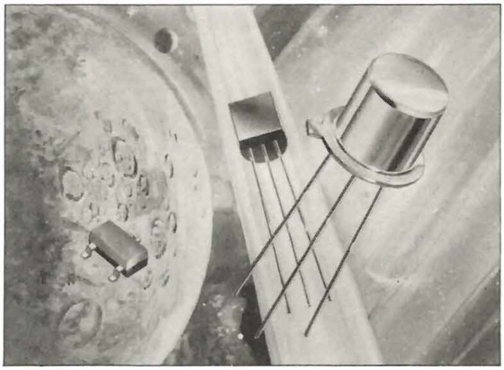
MOTOROLA SMALL-SIGNAL TRANSISTOR DATA

DL126

MOTOROLA INC.



SMALL-SIGNAL TRANSISTOR DATA



MOTOROLA
SMALL-SIGNAL TRANSISTORS

Prepared by
Technical Information Center

This publication presents technical information for the several product families that comprise the Motorola small-signal transistor line. The families include both bipolar and field-effect transistors. These are available in a variety of packages; metal can, plastic, and microminiature. Complete device specifications and typical performance curves are given on individual data sheets, which are grouped by the various families.

A quick comparison of performance characteristics is presented in the easy-to-use selector guides in the first section. The tables will assist in the selection of the proper transistor for a specific application.

Separate sections are included to describe package outline drawings, and to clarify the mysteries of high reliability processing and testing.

The information in this book has been carefully checked and is believed to be accurate; however, no responsibility is assumed for inaccuracies. Furthermore, this information does not convey to the purchaser of semiconductor devices any license under the patent rights to the manufacturer.

Second Printing
Series A

Printed in U.S.A.

Macro-T, Macro-X and TMOS are trademarks of Motorola Inc.

ALPHANUMERIC INDEX

Devices with no page number shown are available from Motorola although not represented in this book. Please contact your nearest Motorola representative for further information.

ALPHANUMERIC INDEX (continued)

Devices with no page number shown are available from Motorola although not represented in this book. Please contact your nearest Motorola representative for further information.

ALPHANUMERIC INDEX (continued)

Motorola Part #	Data Sheet Page #	Selector Guide Page #
2N3227	4-38	1-15
2N3244	4-78	1-16
2N3245	4-78	1-16
2N3249	4-82	-
2N3250	4-86	1-19
2N3250A	4-86	1-19
2N3250AJAN	4-86	1-19
2N3250AJTX	4-86	1-19
2N3250AJTXV	4-86	1-19
2N3251	4-86	1-19
2N3251A	4-86	1-19
2N3251AJAN	4-86	1-19
2N3251AJTX	4-86	1-19
2N3251AJTXV	4-86	1-19
2N3252	4-91	1-15
2N3253	4-91	1-15
2N3253JAN	4-91	1-15
2N3253JANTX	4-91	1-15
2N3299	4-96	-
2N3300	4-96	1-19
2N3301	4-96	-
2N3302	4-96	1-18
2N3303	-	1-15
2N3307	4-97	1-17
2N3308	4-97	-
2N3330	6-4	1-30
2N3330JAN	-	1-44
2N3330JTX	-	1-44
2N3331	6-5	-
2N3368	-	1-31
2N3369	-	1-31
2N3370	-	1-31
2N3425	5-19	-
2N3436	6-6	1-32
2N3437	6-6	1-31
2N3438	6-6	1-31
2N3439	4-99	1-17
2N3439JAN	4-99	1-17
2N3439JTX	4-99	1-17
2N3439JTXV	4-99	1-17
2N3440	4-99	1-17
2N3440JAN	4-99	1-17
2N3440JTX	4-99	1-17
2N3440JTXV	4-99	1-17
2N3444	4-91	1-15
2N3444JAN	4-91	1-15
2N3444JANTX	4-91	1-15
2N3458	6-7	1-32
2N3459	6-7	1-31
2N3460	6-7	1-31
2N3467	4-105	1-16
2N3467JAN	4-105	1-16
2N3467JTX	4-105	1-16
2N3467JTXV	4-105	1-16
2N3468	4-105	1-16
2N3468JAN	4-105	1-16
2N3468JTX	4-105	1-16
2N3468JTXV	4-105	1-16
2N3485	4-57	-
2N3485A	4-57	1-19

Motorola Part #	Data Sheet Page #	Selector Guide Page #
2N3485AJAN	4-57	1-19
2N3485AJTX	4-57	1-19
2N3486	4-57	1-19
2N3486A	4-57	1-19
2N3486AJAN	4-57	1-19
2N3486AJTX	4-57	1-19
2N3494	4-108	1-18
2N3495	4-108	1-18
2N3496	4-108	1-18
2N3497	4-108	1-18
2N3498	4-111	1-17
2N3498JAN	4-111	1-17
2N3498JTX	4-111	1-17
2N3498JTXV	4-111	1-17
2N3499	4-111	1-17
2N3499JAN	4-111	1-17
2N3499JTX	4-111	1-17
2N3499JTXV	4-111	1-17
2N3500	4-111	1-17
2N3500JAN	4-111	1-17
2N3500JTX	4-111	1-17
2N3500JTXV	4-111	1-17
2N3501	4-111	1-17
2N3501JAN	4-111	1-44
2N3501JTX	4-111	1-44
2N3501JTXV	4-111	1-44
2N3506	4-117	1-15
2N3506JAN	4-117	1-15
2N3506JTX	4-117	1-15
2N3506JTXV	4-117	1-15
2N3507	4-117	1-15
2N3507JAN	4-117	1-15
2N3507JTX	4-117	1-15
2N3507JTXV	4-117	1-15
2N3508	4-119	1-15
2N3509	4-119	1-15
2N3510	4-121	-
2N3511	4-121	-
2N3546	4-124	1-15
2N3553	7-7	1-43
2N3553JAN	-	1-44
2N3553JTX	-	1-44
2N3553JTXV	-	1-44
2N3634	4-127	1-16
2N3634JAN	4-127	1-16
2N3634JTX	4-127	1-16
2N3635	4-127	1-16
2N3635JAN	4-127	1-16
2N3635JTX	4-127	1-16
2N3636	4-127	1-16
2N3636JAN	4-127	1-16
2N3636JTX	4-127	1-16
2N3637	4-127	1-18
2N3637JAN	4-127	1-18
2N3637JTX	4-127	1-18
2N3647	4-121	1-15
2N3648	4-121	1-15
2N3673	-	1-19
2N3677	4-133	-
2N3700	4-70	1-18

Devices with no page number shown are available from Motorola although not represented in this book. Please contact your nearest Motorola representative for further information.

ALPHANUMERIC INDEX (continued)

Motorola Part #	Data Sheet Page #	Selector Guide Page #
2N3712	4-134	1-17
2N3724	4-135	1-15
2N3724A	-	1-15
2N3725	4-135	1-15
2N3725A	-	1-15
2N3726	5-20	1-26
2N3727	5-20	1-27
2N3734	4-139	1-15
2N3735	4-139	1-15
2N3736	4-139	1-15
2N3737	4-139	1-15
2N3742	4-141	1-17
2N3743	4-143	1-18
2N3743JAN	4-143	1-18
2N3743JTX	4-143	1-18
2N3762	4-147	1-16
2N3762JAN	4-147	1-16
2N3762JTX	4-147	1-16
2N3762JTXV	4-147	1-16
2N3763	4-147	1-16
2N3763JAN	4-147	1-16
2N3763JANTXV	-	1-16
2N3763JTX	4-147	1-16
2N3764	4-147	-
2N3764JAN	4-147	1-44
2N3764JTX	4-147	1-44
2N3764JTXV	4-147	1-44
2N3765	4-147	-
2N3765JAN	4-147	1-44
2N3765JTX	4-147	1-44
2N3796	6-8	1-33
2N3797	6-8	1-31
2N3798	4-153	1-16
2N3799	4-153	1-16
2N3806	5-22	1-27
2N3807	5-22	1-27
2N3808	5-22	1-27
2N3809	5-22	1-27
2N3810	5-22	1-27
2N3810A	5-22	1-27
2N3810JAN	5-22	1-44
2N3810JTX	5-22	1-44
2N3810JTXV	5-22	1-44
2N3811	5-22	1-27
2N3811A	5-22	1-27
2N3811JAN	5-22	1-44
2N3811JTX	5-22	1-44
2N3811JTXV	5-22	1-44
2N3812	5-22	1-27
2N3813	5-22	1-27
2N3814	5-22	1-27
2N3815	5-22	1-27
2N3816	5-22	1-27
2N3816A	5-22	1-27
2N3817	5-22	1-27
2N3817A	5-22	1-27
2N3819	-	1-34
2N3821	6-11	1-31
2N3821JAN	6-11	1-44
2N3821JTX	-	1-44

Motorola Part #	Data Sheet Page #	Selector Guide Page #
2N3821JTXV	-	1-44
2N3822	6-11	1-32
2N3822JAN	6-11	1-44
2N3822JTX	-	1-44
2N3822JTXV	-	1-44
2N3823	6-13	1-34
2N3823JAN	-	1-44
2N3823JTX	-	1-44
2N3823JTXV	-	1-44
2N3824	6-11	-
2N3838	5-25	1-27
2N3839	7-2	1-38
2N3866	7-9	1-38
2N3866A	7-9	1-44
2N3866AJAN	7-9	1-44
2N3866AJTX	7-9	1-44
2N3866AJTXV	7-9	1-44
2N3866JAN	7-9	1-44
2N3866JTX	7-9	1-44
2N3866JTXV	7-9	1-44
2N3903	2-2	1-2
2N3904	2-2	1-2
2N3905	2-7	1-2
2N3906	2-7	1-2
2N3909	6-14	1-30
2N3909A	6-14	1-31
2N3946	4-156	1-18
2N3947	4-156	1-18
2N3948	7-13	1-42
2N3959	7-15	1-39
2N3960	7-15	1-39
2N3960JAN	-	1-44
2N3960JTX	-	1-44
2N3960JTXV	-	1-44
2N3962	4-162	1-16
2N3963	4-162	1-16
2N3964	4-162	1-16
2N3965	4-162	1-16
2N3966	6-15	-
2N3970	6-16	1-29
2N3971	6-16	1-29
2N3972	6-16	1-30
2N3993	6-17	1-28
2N3993A	6-17	1-28
2N3994	6-17	1-28
2N3994A	6-17	1-28
2N4013	4-164	1-15
2N4014	4-164	1-15
2N4015	5-26	1-27
2N4016	5-26	1-27
2N4026	4-168	1-19
2N4027	4-168	1-19
2N4028	4-168	1-19
2N4029	4-168	1-19
2N4030	4-168	1-16
2N4031	4-168	1-19
2N4032	4-168	1-19
2N4033	4-168	1-16
2N4033JAN	4-168	1-16
2N4033JTX	4-168	1-16

Devices with no page number shown are available from Motorola although not represented in this book. Please contact your nearest Motorola representative for further information.

ALPHANUMERIC INDEX (continued)

Devices with no page number shown are available from Motorola although not represented in this book. Please contact your nearest Motorola representative for further information.

Devices with no page number shown are available from Motorola although not represented in this book. Please contact your nearest Motorola representative for further information.

ALPHANUMERIC INDEX (continued)

Devices with no page number shown are available from Motorola although not represented in this book. Please contact your nearest Motorola representative for further information.

ALPHANUMERIC INDEX (continued)

Devices with no page number shown are available from Motorola although not represented in this book. Please contact your nearest Motorola representative for further information.

ALPHANUMERIC INDEX (continued)

Devices with no page number shown are available from Motorola although not represented in this book. Please contact your nearest Motorola representative for further information.

ALPHANUMERIC INDEX (continued)

Devices with no page number shown are available from Motorola although not represented in this book. Please contact your nearest Motorola representative for further information.

Devices with no page number shown are available from Motorola although not represented in this book. Please contact your nearest Motorola representative for further information.

ALPHANUMERIC INDEX (continued)

Devices with no page number shown are available from Motorola although not represented in this book. Please contact your nearest Motorola representative for further information.

ALPHANUMERIC INDEX (continued)

Devices with no page number shown are available from Motorola although not represented in this book. Please contact your nearest Motorola representative for further information.

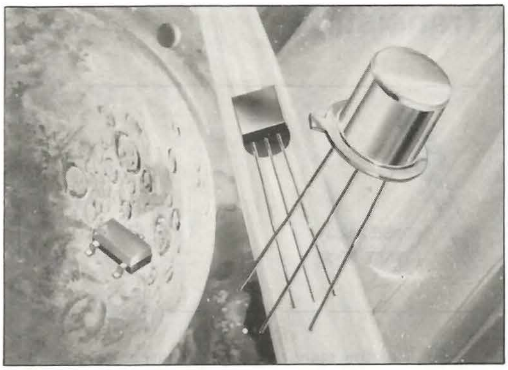
ALPHANUMERIC INDEX (continued)

Devices with no page number shown are available from Motorola although not represented in this book. Please contact your nearest Motorola representative for further information.

ALPHANUMERIC INDEX (continued)

Devices with no page number shown are available from Motorola although not represented in this book. Please contact your nearest Motorola representative for further information.

Devices with no page number shown are available from Motorola although not represented in this book. Please contact your nearest Motorola representative for further information.



The following selector guides highlight transistors that have emerged as the best values in their various categories. Semiconductors are manufactured by "batch" processes; therefore, each "batch" may yield devices with widely varying parameters, creating "families."

A large selection of plastic-encapsulated transistors is offered (TO-92, 1 Watt TO-92, SOT-23, SOT-89, Duals, and Quads).

For those applications where higher power dissipation and hermeticity are required, Motorola offers a full line of transistors in several metal-can packages.

FET's include devices developed for operation from dc to UHF in switching and amplifying applications.

A broad line of high frequency (RF) transistors with F_T's up to 8 GHz are included for amplifiers, oscillators, mixers and switching applications.

Devices which are qualified to JAN, JANTX, JANTXV, and JANS high reliability specifications are so noted in the applicable selector guides.

Selector Guides

1

Table of Contents

1

Plastic-Encapsulated Small-Signal Transistors

CASE 29-02
TO-92

CASE 29-03
1 WATT TO-92

Motorola's small-signal TO-92 plastic transistors encompass hundreds of devices with a wide variety of characteristics for general purpose, amplifier and switching applications. The popular high-volume TO-92 package combines proven reliability, performance, economy and convenience to provide the perfect solution for industrial and consumer design problems. All Motorola TO-92 devices are laser marked for ease of identification and shipped in antistatic containers, as part of Motorola's ongoing practice of maintaining the highest standards of quality and reliability.

In addition to the standard TO-92 devices listed in the following tables, Motorola also offers special electrical selections of these devices. Please contact your Motorola Sales Representative regarding any special requirements you may have.

In each of the following tables, the major specifications of the TO-92 transistor are given for easy comparison.

Motorola TO-92 transistors are available in the radial or axial tape and reel formats. Lead forming to fit TO-5 or TO-18 sockets is also available.

TABLE 1. General-Purpose Transistors

These general-purpose transistors are designed for small-signal amplification from dc to low radio frequencies. They are also useful as oscillators and general-purpose switches. The transistors are listed in order of decreasing breakdown voltage, $V_{(BR)CEO}$.

P_D @ T_A = 25°C = 625 mW)

Device and Polarity		$V_{(BR)CEO}$ Volts	F_T MHz @		I_C mA	H_{FE} @		
NPN	PNP	Min	Min	I_C mA	Max	Min	Max	I_C mA
MPS8099	MPS8599	80	150	10	200	100	300	1.0
MPS-A06	MPS-A56	80	100	10	500	50	—	100
MPS8098	MPS8598	60	150	10	200	100	300	1.0
MPS-A05	MPS-A55	60	100	10	500	50	—	100
MPS651	MPS751	60	75	50	2000	40	—	2000
2N3904	2N3906	40	300	10	200	100	300	10
2N4401	2N4403	40	250	20	600	100	300	150
2N3903	2N3905	40	250	10	200	50	150	100
2N4400	2N4402	40	200	20	600	50	150	150
MPS-A20	MPS-A70	40	125	5.0	100	40	400	5.0
MPS650	MPS750	40	75	50	2000	40	—	2000
MPS6531	MPS6534	40	390†	50	600	90	270	100
MPS2222	MPS2907	30	250	20	600	100	300	150
2N4123	2N4125	30	250	10	200	50	150	2.0
MPS3704	MPS3702	30	100	50	600	100	300	50
MPS6513	MPS6517	30	330†	10	100	90	180	2.0
2N4124	2N4126	25	300	10	200	120	360	2.0
MPS6514	MPS6518	25	480†	10	100	150	300	2.0
MPS6515	MPS6519	25	480	10	100	250	500	2.0
MPS5172		25			100	100	500	10
MPS6560	MPS6562	25	60	10	500	50	200	600
MPS6601	MPS6651	25	100	50	1000	30	150	1000

1 WATT TO-92 (TO-226AE) (P_D @ T_A = 25°C = 1.0 W)

MPS6717	MPS6729	80	50	200	500	80	—	50
MPSW06	MPSW56	80	50	200	500	80	—	50
MPS6716	MPS6728	60	50	200	500	80	—	50
MPSW05	MPSW55	60	50	200	500	80	—	50
MPS6715	MPS6727	40	50	50	1000	50	—	1000
MPSW01A	MPSW51A	40	50	50	1000	50	—	1000
MPS6714	MPS6726	30	50	50	1000	50	—	1000
MPSW01	MPSW51	30	50	50	1000	50	—	1000

†Typ

TABLE 2. High-Speed Saturated Switching Transistors

The transistors listed in this table are specially optimized for high-speed saturated switches. They are heavily gold doped and processed to provide very short switching times and low output capacitance (below 6 pF). The transistors are listed in order of decreasing turn-on time (t_{on}).

Device Type	t_{on} & ns Max	t_{off} @ ns Max	I_C mA	$V_{(BR)CEO}$ Volts Min	h_{FE} @ Min	I_C mA	$V_{CE(sat)}$ @ Volts Max	I_C & mA	I_B mA	f_T @ MHz Min	I_C mA
NPN											
2N4264	25	35	10	15	40	10	0.22	10	1.0	300	10
2N4265	25	35	10	12	100	10	0.22	10	1.0	300	10
MPS3646	18	28	300	15	30	30	0.2	30	3.0	350	30
MPS2369	12	18	10	15	40	10	0.25	10	1.0	500	10
PNP											
MPS3640	25	35	50	12	30	10	0.2	10	1.0	500	10
MPS4258	15	20	10	12	30	50	0.15	10	1.0	700	10
2N5771	15	20	10	15	50	10	0.18	10	1.0	850	10

TABLE 3. RF/UHF/VHF Amplifiers and CATV Transistors

The transistors listed below are high performance, high frequency standard transistors. The transistors are listed in order of decreasing f_T min.

Device Type	f_T MHz Min	f_T @ MHz Typ	I_C mA	C_{cb} pF Max	$V_{(BR)CEO}$ Volts Min	G_{pe} dB Min	NF @ dB Max	f MHz	V_{AGC} @ Min	Gain Reduction dB
MPS5179	900		5.0	1.0	12	15	4.5	200		
MPS-H17	800	1600	5.0	0.9	15	24†	6.0	200		
MPS6543	750	1100	4.0	1.0	25					
MPS-H10	650	1500	4.0	0.65*	25					
MPS-H11	650	1400	4.0	0.7	25					
MPS6547	600	1100	2.0	0.35†	25					
MPS918	600	800	4.0	1.7	15	15	6.0	60		
MPS3563	600	800	8.0	1.7	12	14				
MPS3866	500		50		30	10				
MPS-H08	400	700	3.0	0.3*	30	14	3.5	200	5.0**	30
MPS-H34	500	700	15	0.32	45					
MPS6539	500	1000	4.0	0.7	20		4.5	100		
2N5222	450	1000	4.0	1.3	15					
MPS-H07	400	700	3.0	0.3*	30	18	3.2	100	5.0	30
MPS-H24	400	800	8.0	0.36	30					
MPS-H20	400	750	4.0	0.65	30					
MPS6540	350	700	2.0	0.65	30					
MPS-H32	300	450	4.0	0.22	30	22.5	3.3†	45	5.5†	30
MPS-H30	300	450	4.0	0.65	20	22.5	6.0	45	4.4	30
MPS3693	200	400	10	3.5	45		4.0†	1.0		
MPS3694	200	400	10	3.5	45		4.0†	1.0		
MPS-H04	80	120	1.5	1.6	80		2.0	1.0		
MPS-H05	80	120	1.5	1.6	80		2.0	1.0		
PNP										
MPS-H81	600	700	5.0	0.65*	20					
2N5208	300	600	2.0	1.0	25	22	3.0	100		
MPS-H54	80	130	1.5	1.6	80		2.0	1.0		
MPS-H55	80	130	1.5	1.6	80					

*C_{ce} **I_{AGC} †Typ

TABLE 4. Darlington Transistors

Darlington amplifiers are cascade transistors used in applications requiring very high gain and input impedance. These devices have monolithic construction and are listed in order of decreasing voltage, $V_{(BR)CES}$.

Device and Polarity NPN	PNP	$V_{(BR)CES}$ Volts Min	h_{FE} Min	@ I_C mA	I_C mA Max	f_T MHz Min	@ I_C mA	$V_{CE(sat)}$ Volts Max	@ I_C mA	I_B mA
MPS-A29		100	10000	100	500	125	10	2.0	100	0.1
MPS-A28		80	10000	100	500	125	10	2.0	100	0.1
MPS-A27		60	10000	100	500	125	10	1.5	100	0.1
	MPSA77	60	10000	100	300	125	10	1.5	100	0.1
MPS-A26		50	10000	100	500	125	10	1.5	100	0.1
	MPSA76	50	10000	100	300	125	10	1.5	100	0.1
2N6426		40	30000	100	500	150	10	1.5	500	0.5
2N6427		40	20000	100	500	130	10	1.5	500	0.5
MPSA25		40	10000	100	500	125	10	1.5	100	0.1
	MPSA75	40	10000	100	300	125	10	1.5	100	0.1
MPSA14	MPSA64	30	20000	100	300	125	10	1.5	100	0.1
MPSA13	MPSA63	30	10000	100	300	125	10	1.5	100	0.1
MPSD04	MPSD54	25	1000	100	300	100	10	1.0	100	0.1
MPSA12	MPSA62	20	20000	10	300			1.0	10	0.01
1 Watt TO-92										
MPS6725		50	25K	200	1000	100	200	1.5	1000	2.0
MPS6724		40	25K	200	1000	100	200	1.5	1000	2.0
MPSW45		40	25K	200	1000	100	200	1.5	1000	2.0
MPSW14	MPSW64	3.0	20K	100	1000	125	10	1.5	100	0.1
MPSW13	MPSW63	30	10K	100	1000	125	10	1.5	100	0.1

TABLE 5. Low-Noise Amplifier Transistors

The small-signal transistors listed in this table are characterized for low-noise amplification at low frequencies. The transistors are listed in decreasing order of noise figure (NF).

Device Type	NF dB Typ	@ f*	$BV_{(BR)CEO}$ Volts Min	h_{FE} Min	@ I_C mA	f_T MHz Min	@ I_C mA
NPN							
2N6428	6.0	Audio	50	250	10	100	1.0
2N4123	6.0	Audio	30	50	2.0	250	10
2N6429	5.0	Audio	45	500	10	100	1.0
2N4124	5.0	Audio	25	120	2.0	300	10
2N6428A	4.0 Max	Audio	50	250	10	100	1.0
2N6429A	3.5 Max	Audio	45	500	10	100	1.0
2N5209	3.0 Max	Audio	50	150	10	30	0.5
2N5088	3.0	Audio	30	300	10	50	0.5
MPS6520	3.0	Audio	25	200	2.0	390†	2.0
MPS6521	3.0	Audio	25	300	2.0	390†	2.0
2N5210	2.0 Max	Audio	50	250	10	30	0.5
MPS8097	2.0 Max	Audio	40	250	0.1	200	10
2N5089	2.0 Max	Audio	25	400	10	50	0.5
MPSA18	1.5 Max	Audio	45	500	10	100	1.0
MPSA09	1.4	1.0 kHz	50	100	0.1	30	0.5
PNP							
2N4125	5.0	Audio	30	50	2.0	200	10
2N4126	4.0	Audio	25	120	2.0	250	10
2N5086	3.0	Audio	50	150	10	40	0.5
MPS6522	3.0	Audio	25	200	2.0	340†	2.0
MPS6523	3.0	Audio	25	300	2.0	340†	2.0
MPS4249	3.0	1.0 kHz	60	100	10	100	1.0
2N5087	2.0	Audio	60	250	10	40	0.5
MPS4250	2.0	1.0 kHz	40	250	10	250	1.0
*MPS4250A	2.0	1.0 kHz	60	250	0.1	250	1.0

*Audio = 10 Hz to 15.7 kHz. †Typ

PLASTIC ENCAPSULATED SMALL-SIGNAL TRANSISTORS (continued)

TABLE 6. High-Voltage Transistors

These high-voltage transistors are designed for driving neon bulbs and Nixie® indicator tubes, for direct line operation, and for other applications requiring high-voltage capability at relatively low collector current. The devices are listed in order of decreasing breakdown voltage, $V_{(BR)CEO}$.

Device Type	$V_{(BR)CEO}$ Volts Min	I_C Amp* Max	h_{FE} Min	@ I_C mA	$V_{CE(sat)}$ Volts Max	& I_C mA	I_B mA	f_T MHz Min	@ I_C mA
NPN									
MPS-A44	400	0.3	50	10	0.75	50	5.0	20	10
2N6517	350	0.5	30	30	0.30	10	1.0	40	10
MPS-A45	350	0.3	50	10	0.75	50	5.0	20	10
2N6516	300	0.5	45	30	0.30	10	1.0	40	10
MPS-A42	300	0.5	40	10	0.5	20	2.0	50	10
2N6515	250	0.5	50	30	0.30	10	1.0	40	10
MPS-A43	200	0.5	40	10	0.4	20	2.0	50	10
MPS-D01	200	0.1	20	30				40	10
2N5551	160	0.6	80	10	0.15	10	1.0	100	10
2N5550	140	0.6	60	10	0.15	10	1.0	100	10
MPS-L01	120	0.15	50	10				60	10
1 Watt TO-92									
MPS6735	300	0.3	40	10	2.0	20	2.0	50	10
MPSW10	300	0.3	40	30	0.75	30	3.0	45	10
MPSW42	300	0.3	40	30	0.50	20	2.0	50	10
MPS6734	250	0.3	40	10	2.0	20	2.0	50	10
MPSW43	200	0.3	50	30	0.4	20	2.0	50	10
MPS6733	200	0.3	40	10	2.0	20	2.0	50	10
PNP									
2N6520	350	0.5	30	30	0.30	10	1.0	40	10
2N6519	300	0.5	45	30	0.30	10	1.0	40	10
MPS-A92	300	0.5	40	10	0.8	20	2.0	50	10
2N6518	250	0.5	50	30	0.30	10	1.0	40	10
MPS-A93	200	0.5	40	10	0.7	20	2.0	50	10
MPS-D51	200	0.1	20	30				40	10
2N5401	150	0.6	60	10	0.5	50	0.5	100	10
2N5400	120	0.6	40	10	0.5	50	0.5	100	10
MPS-L51	100	0.6	40	50	0.25	10	1.0	60	10
1 Watt TO-92									
MPSW60	300	0.3	40	30	0.75	20	2.0	60	10
MPSW92	300	0.3	25	30	0.50	20	2.0	50	10
MPSW93	200	0.3	30	30	0.40	20	2.0	50	10

TABLE 7. Choppers

Devices are listed in decreasing ($V_{(BR)EBO}$

Device Type	$V_{(BR)EBO}$ Volts Min	I_C Amp* Max	h_{FE} Min	@ I_C mA	$V_{CE(sat)}$ Volts Max	& I_C mA	I_B mA	f_T MHz Min	@ I_C mA
NPN									
MPSA17	15	100	200	5.0	0.25	10	1.0	100	5.0
MPSA16	12	100	200	5.0	0.25	10	1.0	80	5.0
PNP									
MPS404A	25	150	30	12	0.20	24	1.0		
MPS404	12	150	30	12	0.20	24	1.0		

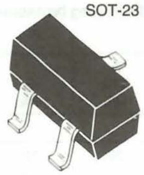
TABLE 8. Dual Diodes

Dual diodes designed for use in low cost biasing, steering, and voltage doubler applications including series, common cathode and common anode diodes.

Device Type	Description	$V_{(BR)}$ Volts Min	@ $I_{(BR)}$ µA	I_R µA Max	@ V_R Volts	V_F Volts Min/Max	@ I_F mA	$C_{VR} = 0$ pF Max	t_{rr} ns Max
MSD6100	Switching	100	100	0.1	50	0.67/0.82	10	1.5	4.0
MSD6102	Common Cathode	70	100	0.1	50	0.67/1.0	10	3.0	100
MSD6150	Common Anode	70	100	0.1	50	–/1.0	10	8.0	100

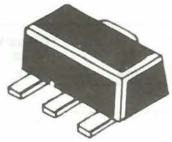
Microminiature Products

SOT-23



CASE 318
TO-236AA
TO-236AB

SOT-89



CASE 345-01

Microminiature Space Saving Alternatives for Discrete Devices

A wide variety of discrete components from Motorola's repertoire of reliability-proven semiconductor processes and geometries are available in SOT (Small Outline Transistor) packages. Products include Bipolar and Field-Effect Transistors; Switching, Zener and Varactor Diodes; and Silicon Controlled Rectifiers. The surface-mounted SOT devices are currently being used by circuit designers on Printed Circuit Boards and Ceramic Substrate.

Some of the significant features of the SOT devices are:

- *Complete Pretest Capability* — all SOT's are 100% electrically tested.
- *Handling and Assembly Ease* — SOT's can be placed on substrates either manually or by using automated handling equipment.
- *Reliability* — SOT's are subjected to the same rigid reliability test performed on all Motorola plastic packages.
- *Small Size/Less Weight* — Considerable size reduction and weight-saving is achieved in circuit designs using SOT technology.
- *Broad Line* — Currently, Motorola offers over 250 standard discrete devices in the SOT packages. (Inquiries regarding customers' special requirements are invited.)
- *Marking Capability* — A multi-digit code is *laser* marked on every SOT device.
- *Multi-Sources* — Although Motorola was the first domestic supplier of SOT's, today there are several U.S. manufacturers, as well as many foreign sources for these devices.
- *Packaging* — Motorola standard shipping method for SOT's is in vials; additionally, in conjunction with the industry trend to use automatic placement equipment for microminiature components, Motorola offers the SOT-23 packaged in the 8mm tape and reel format.
- *Standard SOT-23 VS Low Profile SOT-23* — Motorola offers both the standard SOT-23 outline (TO-236AA) and the new "Low Profile" SOT-23 (TO-236AB). The only difference is the clearance from the bottom of the package to the surface of the substrate:

Device	Millimeters		Inches	
	Min	Max	Min	Max
Standard SOT-23	0.10	0.25	0.004	0.0098
Low Profile SOT-23	0.01	0.10	0.0005	0.0040

The "Low Profile" package is primarily designed for customers using two-sided printed circuit boards with the SOT-23's mounted on the "bottom side" of the board, and with the nonsurface mounted device on the "top side." Contact your Motorola representative for ordering instructions on "Low Profile" SOT-23's.

TABLE 1. General-Purpose SOT-23 Transistors

Pinout: 1-Base, 2-Emitter, 3-Collector

Devices are listed in order of descending breakdown voltage.

NPN

Device Type	Marking	$V_{BR(CEO)}$	h_{FE} Min	Max	@ I_C (mA)	f_T Min (MHz)
BCX70K	AK	45	380	630	2	125
BCX70J	AJ	45	250	460	2	125
BCW72	K2	45	200	450	2	—
BCX70H	AH	45	180	310	2	125
BCW66G	EG	45	160	400	100	100
BCX70G	AG	45	120	220	2	125
BCW71	K1	45	110	220	2	—
BCW66F	EF	45	100	250	100	100
BCX19	U1	45	100	600	100	200
MMBT930	1X	45	100	300	1	30
MMBC1623L7	L7	40	300	600	1	200
MMBC1623L6	L6	40	200	400	1	200
MMBC1623L5	L5	40	135	270	1	200
BSS79C	CF	40	100	300	150	250
MMBT2222A	1P	40	100	300	150	200
MMBT3904	1A	40	100	300	10	200

MICROMINIATURE PRODUCTS (continued)

TABLE 1. General-Purpose SOT-23 Transistors (continued)

Pinout: 1-Base, 2-Emitter, 3-Collector

Devices are listed in order of descending breakdown voltage.

NPN

Device Type	Marking	$V_{BR(CEO)}$	h_{FE} Min	h_{FE} Max	h_{FE} @ I_C (mA)	f_T Min (MHz)
MMBT4401	2X	40	100	300	150	250
MMBC1623L4	L4	40	90	180	1	200
MMBC1623L3	L3	40	60	120	1	200
MMBT3903	1Y	40	50	150	10	250
BSS79B	CE	40	40	120	150	250
MMBTA20	1C	40	40	400	5	125
MMBC1622D8	D8	35	450	900	5	100
MMBC1622D7	D7	35	300	600	5	100
MMBC1622D6	D6	35	200	400	5	100
BCW60D	AD	32	380	630	2	125
BCW60C	AC	32	250	460	2	125
BCW65C	EC	32	250	630	100	100
BCW60B	AB	32	180	310	2	125
BCW65B	EB	32	160	400	100	100
BCW60A	AA	32	120	220	2	125
BCW65A	EA	32	100	250	100	100
MMBT2222	1B	30	100	300	150	250
MMBB601T	ZA	25	400	650	2	—
BCW20	U2	25	100	600	100	—
MMBT4124	ZC	25	60	—	50	300
BCW33	D3	20	420	00	2	—
BCW32	D2	20	200	450	2	—
BCW31	D1	20	110	220	2	—

PNP

Device Type	Marking	$V_{BR(CEO)}$	h_{FE} Min	h_{FE} Max	h_{FE} @ I_C (mA)	f_T Min (MHz)
BSS82C	CM	60	100	300	150	100
MMBT2907A	2F	60	100	300	150	200
MMBA811C8	C8	45	450	900	5	50
BCX71K	BK	45	380	630	2	—
MMBA811C7	C7	45	300	600	5	50
BCX71J	BJ	45	250	460	2	—
BCW70	H2	45	215	500	2	—
MMBA811C6	C6	45	200	400	5	50
BCX71H	BH	45	180	310	2	—
BCW68G	DG	45	160	400	100	100
MMBA811C5	C5	45	135	270	5	50
BCW69	H1	45	120	260	2	—
BCX71G	BG	45	120	220	2	—
BCW68F	DF	45	100	250	100	100
BCX17	T1	45	100	600	100	100
MMBA813S4	S4	45	100	200	50	100
MMBA813S3	S3	45	75	150	50	100
MMBA813S2	S2	45	50	100	50	100
MMBA812M7	M7	40	300	600	1	150
MMBA812M6	M6	40	200	400	1	150
MMBA812M5	M5	40	135	270	1	150
MMBT2907	2B	40	100	300	150	200
MMBT3906	2A	40	100	300	10	250
MMBT4403	2T	40	100	300	150	200
MMBA812M4	M4	40	90	180	1	150
MMBA812M3	M3	40	60	120	1	150
BSS80B	CH	40	40	120	150	200
BSS80C	CJ	40	40	120	150	200
MMBTA70	2C	40	40	400	5	125
BCW61D	BD	32	380	630	2	—
BCW61C	BC	32	250	460	2	—
BCW67C	EC	32	250	630	100	100
BCW61B	BB	32	180	310	2	—

MICROMINIATURE PRODUCTS (continued)

TABLE 1. General-Purpose SOT-23 Transistors (continued)
Pinout: 1-Base, 2-Emitter, 3-Collector

Devices are listed in order of descending breakdown voltage.

PNP

Device Type	Marking	$V_{BR(CEO)}$	h_{FE} Min	h_{FE} Max	h_{FE} @ I_C (mA)	f_T Min (MHz)
BCW67B	DB	32	160	400	100	100
BCW61A	BA	32	120	220	2	—
BCW67A	DA	32	100	250	100	100
MMBT4125	ZD	30	60	80	50	200
MMBB709T	ZB	25	400	650	2	—
MMBB709S	ZB	25	290	460	2	—
BCX18	T2	25	100	600	100	—
BCW30	C2	20	215	500	2	—
BCW29	C1	20	120	260	2	—

TABLE 2. SOT-23 Switching Transistors
Pinout: 1-Base, 2-Emitter, 3-Collector

Device	Marking	Switching Time (ns) T_{ON}	Switching Time (ns) T_{OFF}	$V_{BR(CEO)}$	h_{FE} Min	h_{FE} Max	h_{FE} @ I_C (mA)	f_TMin (MHz)
NPN								
MMBT2369	1J	12	18	15	40	120	10	—
BSX39	02	12	18	14	40	200	10	—
BSV52	B2	12	18	12	40	120	10	400
MMBC1621B4	B4	20	40	20	90	180	1.0	200
MMBC1621B3	B3	20	40	20	60	120	1.0	200
MMBC1621B2	B2	20	40	20	40	80	1.0	20
PNP								
MMBT3640	2J	25	35	12	30	120	10	500

TABLE 3. SOT-23 Transistors, VHF/UHF Amplifiers, Mixers, Oscillators
Pinout: 1-Base, 2-Emitter, 3-Collector

Device	Marking	f_T Min (GHz)	f_T @ I_C (mA)	$V_{BR(CEO)}$	C_{ob} Max (pF)
NPN					
MMBT3960A	1T	1.600	30	8	2.00
MMBT3960	15	1.600	30	3	2.00
MMBT6543	3F	0.750	4	25	1.00
MMBTH10	3E	0.650	4	25	.70
MMBC1321Q2	Q2	0.600	2	25	1.80
MMBC1321Q3	Q3	0.600	2	25	1.80
MMBC1321Q4	Q4	0.600	2	25	1.80
MMBC1321Q5	Q5	0.600	2	25	1.80
MMBT918	3B	0.600	4	15	1.70
MMBTH24	3A	0.400	8	30	.36
MMBC1009F1	F1	0.150	1	25	3.50
MMBC1009F2	F2	0.150	1	25	3.50
MMBC1009F3	F3	0.150	1	25	3.50
MMBC1009F4	F4	0.150	1	25	3.50
MMBC1009F5	F5	0.150	1	25	3.50
PNP					
MMBT4260	2R	2.000	10	10	2.50
MMBT4261	2S	2.000	10	10	2.50
MMBTH81	3D	0.600	5	20	.85

MICROMINIATURE PRODUCTS (continued)

TABLE 4. Chopper Transistors
Pinout: 1-Base, 2-Emitter, 3-Collector

PNP

Device	Marking	$V_{BR(EBO)}$	$V_{BR(CEO)}$	H_{FE} Min	H_{FE} Max	H_{FE} @ I_C (mA)
MMBT404	2M	12	24	30	400	12
MMBT404A	2N	25	35	30	400	12

TABLE 5. SOT-23 Darlington Transistors
Pinout: 1-Base, 2-Emitter, 3-Collector

Device	Marking	H_{FE} Min	H_{FE} Max	H_{FE} @ I_C (mA)	VBR(CEO)	$V_{CE(sat)}$ Max (V)
NPN						
MMBTA14	1N	20 K	—	100	30	1.5
MMBT6427	1V	10 K	100 K	10	40	1.5
MMBTA13	1M	10 K	—	100	30	1.5
PNP						
MMBTA64	2V	10 K		10	30	1.5
MMBTA63	2U	5.0 K		10	30	1.5

TABLE 6. Low-Noise SOT-23 Transistors
Pinout: 1-Base, 2-Emitter, 3-Collector

Device	Marking	NF dB (Typ)	$V_{BR(CEO)}$	H_{FE} Min	H_{FE} Max	H_{FE} @ I_C (mA)	f_T Min (MHz)
NPN							
MMBT5088	1Q	1.0	30	300	900	1.0	50
MMBT5089	1R	1.0	25	400	1200	1.0	50
MMBT2484	1U	3.0	60	100	600	0.01	15
MMBT6428	1K	3.0	50	250	650	1.0	100
MMBT6429	1L	3.0	45	500	1250	1.0	100
PNP							
MMBT5087	2Q	1.0	50	250	800	1.0	40
MMBT5086	2P	1.5	50	150	500	1.0	40

TABLE 7. High-Voltage SOT-23 Transistors
Pinout: 1-Base, 2-Emitter, 3-Collector

Device	Marking	$V_{BR(CEO)}$	h_{FE} Min	h_{FE} Max	h_{FE} @ I_C (mA)	f_T Min (MHz)
NPN						
MMBTA42	1D	300	40	—	10	50
MMBTA43	1E	200	40	—	10	50
MMBC1654N5	N5	160	150	330	15	120
MMBC1654N6	N6	160	100	220	15	120
MMBC1654N7	N7	160	50	130	15	120
MMBT5550	1F	150	60	250	10	100
MMBC1653N2	N2	130	150	330	15	120
MMBC1653N3	N3	130	100	220	15	120
MMBC1653N4	N4	130	50	130	15	120
PNP						
MMBTA92	2D	300	40	—	10	50
MMBTA93	2E	200	40	—	10	50
MMBT5401	2L	150	60	240	10	100

MICROMINIATURE PRODUCTS (continued)

TABLE 8. SOT-23 Driver Transistors
Pinout: 1-Base, 2-Emitter, 3-Collector

NPN

Device	Marking	$V_{BR(CEO)}$	h_{FE} Min	Max	@ I_C (mA)	f_T Min (MHz)
MMBTA06	1G	80	50	—	10	100
BSS64	AM	80	20	80	4.0	50
MMBTA05	1H	60	50	—	10	100

PNP

Device	Marking	$V_{BR(CEO)}$	h_{FE} Min	Max	@ I_C (mA)	f_T Min (MHz)
BSS63	BM	100	30	—	10	50
MMBTA56	2G	80	50	—	10	100
MMBTA55	2H	60	50	—	10	100

TABLE 9. RF SOT-23 Transistors
Pinout: 1-Base, 2-Emitter, 3-Collector

NPN

		f_T			NF			MAG			
Device	Marking	Typ (GHz)	I_C (mA)	V_{CE} (V)	Typ (dB)	@ I_C (mA)	V_{CE} (V)	Typ (dB)	@ I_C (mA)	V_{CE} (V)	f (MHz)
MMBR571	7X	8.0	50	10	2	10	5.0	12	30	5	1000
MMBR930	7C	5.5	30	5.0	1.9	2.0	5.0	15.5	30	5.0	500
MMBR920	7B	5.0	14	10	2.4	2.0	10	17	14	10	1000
MMBR911	7P	5.0	30	10	2.5	5	5.0	12	30	10	1000
BRF92	P1	4.5	14	10	3.0	3.0	1.5	—	—	—	—
BFR92S	P5	4.5	14	10	3.0	3.0	1.5	—	—	—	—
BFR93	R1	4.5	30	5.0	3.0	2.0	5.0	—	—	—	—
BFR93S	R6	4.5	30	5.0	3.0	2.0	5.0	—	—	—	—
MMBR901	7A	4.0	15	10	2.3	5.0	6.0	10.5	15	10	1000
MMBR931	7D	3.5	1.0	1.0	2.7	0.5	1.0	18	1.0	1.0	500
MMBR2060	7E	2.5	20	10	2.0	1.5	10	13	20	10	500
MMBR5031	7G	2.0	5.0	6.0	1.9	1.0	6.0	13.5	5.0	6.0	450
MMBR5179	7H	1.5	5.0	6.0	4.0	1.5	6.0	11.0	5.0	6.0	450
MMBR2857	7K	1.0	4.0	10	—	—	—	—	—	—	—
BFS17	E1	1.0	2.0	5.0	5.0	2.0	5.0	—	—	—	30
BFS17S	E5	1.0	2.0	5.0	5.0	2.0	5..0	—	—	—	30

PNP

Device	Marking	Typ (GHz)	I_C (mA)	V_{CE} (V)	Typ (dB)	@ I_C (mA)	V_{CE} (V)	Typ (dB)	@ I_C (mA)	V_{CE} (V)	f (MHz)
MMBR536	7R	4.0	20	5	3.0	3.0	5.0	10	15	5	1000
MMBR4957	7F	2.0	2.0	10	2.5	2.0	10	14.5	2.0	10	450

TABLE 10. RF Junction Field-Effect SOT-23 Transistors
Pinout: 1-Base, 2-Emitter, 3-Collector

N-CHANNEL

		NF		Y_{fs}			
Device	Marking	Typ (dB)	f (MHz)	Min (mmhos)	Max (mmhos)	V_{DS} (V)	$V_{(BR)GSS}$
MMBFU310	6C	1.5	100	10	18	10	−25
MMBF5484	6B	2.0	100	3.0	6.0	15	−25
MMBF5486	6H	2.0	100	4.0	8.0	15	−25
MMBF4416	6A	2.0	100	4.5	7.5	15	−30
MMBFJ310	6T	4.0	450	8.0	18	10	−25

TABLE 11. General-Purpose Field-Effect SOT-23 Transistors

Pinout: 1-Base, 2-Emitter, 3-Collector

N-CHANNEL

Device	Marking	$V_{(BR)GSS}$	Y_{fs} Min (mmhos)	Y_{fs} Max (mmhos)	V_{DS} (V)	I_{DSS} Min (mA)	I_{DSS} Max (mA)
MMBF5457	6D	−25	1.0	5.0	15	1.0	5.0
BFR30	M1	−25	1.0	4.0	10	4.0	10
BFR31	M2	−25	1.5	4.5	10	1.0	5.0
MMBF5459	6L	−25	2.0	6.0	15	4.0	16
P-CHANNEL							
MMBF5460	6E	40	1.0	4.0	15	1.0	5.0

TABLE 12. Chopper/Switches, Junction Field-Effect SOT-23 Transistors

N-CHANNEL

Device	Marking	$r_{DS(on)}$ Max (Ohms)	t_{off} Max (ns)	$V_{(BR)GSS}$	$V_{(GS)\,off}$ Min (V)	$V_{(GS)\,off}$ Max (V)	I_{DSS} Min (mA)	I_{DSS} Max (mA)
MMBF4391	6J	30	20	−30	−4.0	−10	50	150
MMBF4860	6F	40	50	−30	−2.0	−6.0	20	100
MMBF4392	6K	60	35	−30	−2.0	−5.0	25	75
MMBF4393	6G	100	55	−30	−0.5	−3.0	5.0	30

TABLE 13. SOT-23 Switching Diodes (Dual Unless Otherwise Noted)

Diode Pinout: Noted Below

Device	Marking	Description		t_{rr} Max (ns)	V_{BR} Min (V)	I_R Max (μA)	V_F Min (V)	V_F Max (V)	V_F @ I_F (mA)	C_{VR} Max (pF)
MMBD2836	A2	Common Anode	(5)	6(1)	75	0.1	—	1.0	10	4.0
BAW56	A1	Common Anode	(5)	6(1)	70	2.5	—	1.1	50	1.5
MMBD2835	A3	Common Anode	(5)	6(1)	35	0.1	—	1.0	10	4.0
BAV74	JA	Common Cathode	(3)	2(2)	50	0.1	—	1.0	100	2.0
MMBD2838	A6	Common Cathode	(3)	6(1)	75	0.1	—	1.0	10	4.0
BAV70	A4	Common Cathode	(3)	6(1)	70	2.5	—	1.1	50	1.5
MMBD2837	A5	Common Cathode	(3)	6(1)	35	0.1	—	1.0	10	4.0
MMBD6100	5B	Common Cathode	(3)	15(1)	70	0.1	0.85	1.1	100	2.5
MMBD914	5D	Single	(6)	4(2)	100	0.05	—	1.0	10	4.0
BAS16	A6	Single	(6)	6(1)	75	1.0	—	0.715	1.0	2.0
BAL99	TF	Single	(7)	6(1)	70	2.5	—	1.1	50	1.5
MMBD6050	5A	Single	(6)	10(1)	70	0.1	0.85	1.1	100	2.5
BAV99	A7	Series	(4)	6(1)	70	2.5	—	1.1	50	1.5
MMBD7000	5C	Series	(4)	15(1)	100	0.3	0.75	1.1	100	1.5

NOTES: (1) $I_F = I_R = 10$ mA, $V_R = 5.0$ V, $I_{RR} = 1.0$ mA
(2) $I_F = I_R = 10$ mA, $V_R = 6.0$ V, $I_{RR} = 1.0$ mA
(3) Pinout: 1-Anode, 2-Anode, 3-Cathode
(4) Pinout: 1-Anode, 2-Cathode, 3-Cathode and Anode
(5) Pinout: 1-Cathode, 2-Cathode, 3-Anode
(6) Pinout: 1-Anode, 2-N.C., 3-Cathode
(7) Pinout: 1-N.C., 2-Anode, 3-Cathode

MICROMINIATURE PRODUCTS (continued)

TABLE 14. SOT-23 Tuning Diodes

Tuning Diode Pinouts: 1-Anode, 2-N.C., 3-Cathode

		BV_R		C_T			Capacitance Ratio		Q			R_S	V_F		I_R	
Device	Marking	Min (V)	@ I_R (μA)	Min (pF)	Max (pF)	@ V_R (V)	Min	Max	Min	@ V_R (V)	& f (MHz)	Max (ohms)	Max (V)	@ I_F (mA)	Max (μA)	@ V_R (V)
TUNING DIODES																
MMBV2097	4K	30	10	.8	1.2	4	2	2.6	325	4	100	—	—	—	.02	25
MMBV2098	4L			1.8	2.7			2.8								
MMBV105G	4E	30	10	1.8	2.8	2.5	4	6	150	(1)	100	—	—	—	.05	28
MMBV2101	4G			6.1	7.5	4	2.5	3.3	450	4	50				.02	25
MMBV2103	4H			9.0	11		2.6		400			—	—	—		
MMBV3102	4C	30	10	20	25	3	4.5	—	300	3	50	—	—	—	.1	25
MMBV2108	4X	30	10	24.3	29.7	4	2.7	3.3	300	4	50	—	—	—	.02	25
MMBV109	4A	30	10	26	32	.3	5	6.5	280	3	50	—	—	—	.02	25
MMBV2109	4J	30	10	29.7	36.3	4	2.7	3.3	200	4	50	—	—	—	.02	25
"PIN" CHANNEL SWITCH																
MMBV3401	4D	35	10	—	1	20	—	—	—	—	—	.7	—	—	.1	25
HOT CARRIER DIODES																
MMBD101	4M	4	10	—	1	0	—	—	—	—	—	—	.6	10	.25	3
MMBD352 (Dual)	5G	4	.25	—			—	—	—	—	—	—	.50			
MMBD501	5F	50	10	—		20	—	—	—	—	—	—	1.2		.2	25

Notes: (1) Voltage such that C_T = 9.0 pF.

TABLE 15. SOT-23 Zener Diodes

Pinout 1-Anode, 2-N.C., 3-Cathode (Tolerance ± 5%)

VZ (Nom) Volts	U.S. Standards	Device Marking	Pro-Electron Equivalent	Device Marking
3.3	MMBZ5226	8A		
3.6	MMBZ5227	8B		
3.9	MMBZ5228	8C		
4.3	MMBZ5229	8D		
4.7	MMBZ5230	8E	BZX84C4V7	Z1
5.1	MMBZ5231	8F	BZX84C5V1	Z2
5.6	MMBZ5232	8G	BZX84C5V6	Z3
6.0	MMBZ5233	8H		
6.2	MMBZ5234	8J	BZX84C6V2	Z4
6.8	MMBZ5235	8K	BZX84C6V8	Z5
7.5	MMBZ5236	8L	BZX84C7V5	Z6
8.2	MMBZ5237	8M	BZX84C8V2	Z7
8.7	MMBZ5238	8N		
9.1	MMBZ5239	8P	BZX84C9V1	Z8
10.0	MMBZ5240	8Q	BZX84C10	Z9
11.0	MMBZ5241	8R	BZX84C11	Y1
12.0	MMBZ5242	8S	BZX84C12	Y2
13.0	MMBZ5243	8T	BZX84C13	Y3
14.0	MMBZ5244	8U		
15.0	MMBZ5245	8V	BZX84C15	Y4
16.0	MMBZ5246	8W	BZX84C16	Y5
17.0	MMBZ5247	8X		
18.0	MMBZ5248	8Y	BZX84C18	Y6
19.0	MMBZ5249	8Z		
20.0	MMBZ5250	81A	BZX84C20	Y7
22.0	MMBZ5251	81B	BZX84C22	Y8
24.0	MMBZ5252	81C	BZX84C24	Y9

TABLE 15. SOT-23 Zener Diodes (continued)

Pinout 1-Anode, 2-N.C., 3-Cathode (Tolerance ± 5%)

VZ (Nom) Volts	U.S. Standards	Device Marking	Pro-Electron Equivalent	Device Marking
25.0	MMBZ5253	81D		
27.0	MMBZ5254	81E	BZX84C27	Y10
28.0	MMBZ5255	81F		
30.0	MMBZ5256	81G	BZX84C30	Y11
33.0	MMBZ5257	81H	BZX84C33	Y12

TABLE 16. SOT-23 Silicon Controlled Rectifier

Rectifier Pinouts: 1-Cathode, 2-Gate, 3-Anode

Device	Marking	I_F (mA)	V_{FXM} (mA)	I_{GT} (μA)	V_{GT} (V)	I_H (mA)
MMBS5062	5T	500	100	200	.8	5
MMBS5061	5S	500	50	200	.8	5
MMBS5060	5R	500	25	200	.8	5

TABLE 17. SOT-23 Silicon Programmable Unijunction Transistors

Transistor Pinouts: 1-Cathode, 2-Gate, 3-Anode

Device	Marking	I_{TRM} (Amp) (1)	I_{TSM} (Amp) (2)	Max (μA) Ip (3)	Min (V) V_T	Max (V)	Max (μA) I_V (3)	Max (V) V_F
MMBPU131	5Z	1	1	2	.2	.7	50	1.5

NOTES:

1. Repetitive Peak Forward Current
   100 μs Pulse Width
   1.0% Duty Cycle
2. Non-Repetitive Peak Forward Current
   10 μs Pulse Width
3. V_S = 10 Vdc, R_G = 1.0 mΩ

TABLE 18. SOT-89 Transistors

Pinout: 1-Base, 2-Collector, 3-Emitter

General Purpose

NPN

Device	$V_{BR(CEO)}$	h_{FE} Min	h_{FE} Max	h_{FE} @ I_C (mA)	f_T Min (MHz)
BCX56	80	40	160	150	50
BCX55	60	40	160	150	50
BCX54	45	40	250	150	50
MXT3904	40	100	300	10	300
BCX68	20	85	375	500	65

PNP

Device	$V_{BR(CEO)}$	h_{FE} Min	h_{FE} Max	h_{FE} @ I_C (mA)	f_T Min (MHz)
BCX53	80	40	160	150	50
BCX52	60	40	160	150	50
BCX51	45	40	250	150	50
MXT3906	40	100	300	10	250
BCX69	20	85	375	500	65

TABLE 18. SOT-89 Transistors (continued)

Pinout: 1-Base, 2-Collector, 3-Emitter

High Voltage

NPN

MXTA44	400	50	200	10	—
MXTA42	300	40	—	10	50
MXTA43	200	50	200	30	—

PNP

MXTA92	300	40	—	10	50
MXTA93	200	30	150	30	50

Darlingtons

Device	h_{FE} Min	h_{FE} Max	h_{FE} @ I_C (mA)	$V_{BR(CBO)}$	$V_{CE(sat)}$ Max (V)
NPN					
MXTA27	10 K	—	10	60	1.5
MXTA14	10 K	—	10	30	1.5
PNP					
MXTA77	10 K	—	10	60	1.5

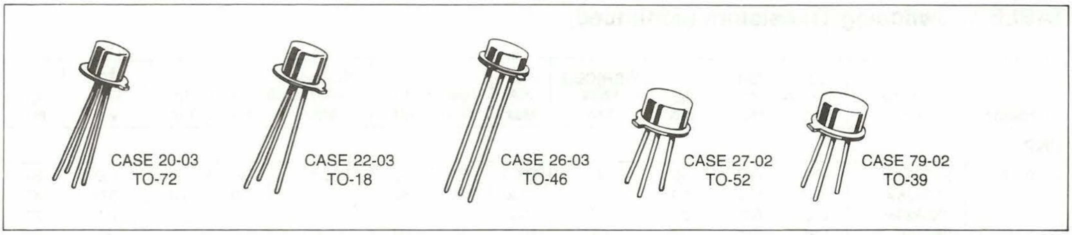
RF

NPN

Device	f_T Min (MHz)	f_T I_C (mA)	$V_{BR(CEO)}$	h_{FE} Min	h_{FE} Max	h_{FE} I_C (mA)
BFQ19	4000	50	15	25	—	50
BFQ18A	3200*	—	15	25	—	50
MXR5943	1200	50	30	25	300	50
BFQ17	1200	150	25	25	—	50
MXR3866	500	50	30	10	200	50
PNP						
MXR5583	1000	40	30	25	100	100
MXR5160	500	50	40	10	—	50

*Typ

Metal Small-Signal Transistors



Motorola Small-Signal Metal Can Transistors are designed for use as General-Purpose Amplifiers, High-Speed Switches, High-Voltage Amplifiers, Low-Level/Low-Noise Amplifiers, High-Frequency Oscillators, Choppers, and Darlingtons. These devices are manufactured in a variety of packages, i.e., TO-18, TO-39, TO-46, TO-52, and TO-72.

The following selector guide tables also indicate those Motorola small-signal metal can transistors which are qualified to MIL-19500 high-rel requirements. Devices are available in the JAN, JANTX, JANTXV and JANS versions as specified.

TABLE 1. Switching Transistors

The following devices are intended for use in general-purpose switching and amplifier applications. Within each package group shown, the devices are listed in order of decreasing turn-on time (t_{on}).

Package	Device Type	t_{on} ns Max &	t_{off} ns Max @	I_C mA	$V_{(BR)CEO}$ Volts Min	I_C mA Max	h_{FE} Min @	I_C mA	$V_{CE(sat)}$ Volts Max @	I_C mA @	I_B mA	f_T MHz Min	I_C mA
NPN													
TO-18	2N2540	40	40	150	30		100	150	0.45	150	15	250	20
	2N914**	40	40	200	15	150	12	10	0.7	200	20	300	20
	2N4014	35	60	500	50	1000	35	500	0.52	500	50	300	50
	2N4013	35	60	500	30	1000	35	500	0.42	500	50	300	50
	2N2501	15	25	300	20		10	500	0.3	50	5.0	350	10
	2N2369	12	18	100	15	500	20	100	0.25	10	1.0	500	10
	2N2369A†	12	18	10	15	200	40	10	0.2	10	1.0	500	10
	2N3227	12	18	100	20	50	30	100	0.25	10	1.0	500	10
TO-39	2N3444**	50	70	500	50		20	500	0.6	500	50	175	50
	2N3253**	50	70	500	40		25	500	0.6	500	50	175	50
	2N3735#	48	60	1000	50	1500	20	1000	0.5	500	50	250	50
	2N3734	48	60	1000	50	1500	30	1000	0.5	500	50	250	50
	2N3252	45	70	500	30		30	500	0.5	500	50	200	50
	2N3506#	45	90	1500	40	3000	40	1500	1.0	1500	150	60	100
	2N3507#	45	90	1500	50	3000	30	1500	1.0	1500	150	60	100
	2N3725	35	60	500	50	2000	35	500	0.52	500	50	300	50
	2N3725A	35	60	500	30	1200	35	500	0.52	500	50	300	50
	2N3724	35	60	500	30	2000	35	500	0.42	500	50	300	50
	2N3724A	35	60	500	30	1200	35	500	0.42	500	50	300	50
	MM5262	30	60	1000	50	2000	25	1000	0.8	1000	100	350(typ)	50
	2N5861	25	60	500	50	2000	25	500	0.5	500	50	200	50
	2N3303	15	25	1000	—	1000	20	10	0.7	1000	100	450	100
TO-46	2N3736	48	60	1000	30	1500	30	1000	0.5	500	50	250	50
	2N3737#	48	60	1000	50	1500	20	1000	0.5	500	50	250	50
	2N3647	20	25	150	10	500	25	150	0.4	150	15	350	15
	2N3648	16	18	150	15	500	30	150	0.4	150	15	450	15
	2N3508	12	18	10	20	500	40	10	0.25	10	1.0	500	10
	2N3509	12	18	10	20	500	100	10	0.25	10	1.0	500	10
TO-52	MM1748	6.0	15	10	—	150	20	10	—	—	—	600	5.0
	MM1748A	10	15	10	—	150	20	10	—	—	—	600	5.0
PNP													
TO-18	2N2894	60	90	30	12	200	40	30	0.2	30	3.0	400	30
	2N869A**	50	80	30	18	200	40	30	0.2	30	3.0	400	10
	2N3546	40	30	50	12		25	50	0.25	50	5.0	700	10
	2N4208	15	20	10	12	200	30	10	0.15	10	1.0	700	10
	MM4258	15	20	10	12	200	30	10	0.15	10	1.0	700	10
	2N4209	15	20	10	15	200	50	10	0.6	50	5.0	850	10

*JAN available **JAN/JANTX available †JAN/JANTX/JANTXV/JANS available #JAN/JANTX/JANTXV available

METAL SMALL-SIGNAL TRANSISTORS (continued)

TABLE 1. Switching Transistors (continued)

Package	Device Type	t_{on} ns Max	& t_{off} ns Max	@ I_C mA	$V_{(BR)CEO}$ Volts Min	I_C mA Max	h_{FE} Min	@ I_C mA	$V_{CE(sat)}$ Volts Max	@ I_C mA	@ I_B mA	f_T MHz Min	I_C mA
PNP													
TO-39	2N3634#	400	600	50	140	1000	50	50	0.5	50	5.0	150	30
	2N3635#	400	600	50	140	1000	100	50	0.5	50	5.0	200	30
	2N3636#	400	600	50	175	1000	50	50	0.5	50	5.0	150	30
	2N4036	110	700	150	65	1000	40	150	0.65	150	15	60	50
	2N4030	100	240(typ)	500	60	1000	15	1000	1.0	1000	100	100	50
	2N4031	100	240(typ)	500	80	1000	10	1000	0.5	500	50	100	50
	2N4032	100	240(typ)	500	60	1000	40	1000	1.0	1000	100	150	50
	2N4033#	100	240(typ)	500	80	1000	25	1000	0.5	500	50	150	50
	2N4406	75	225	1000	80	1500	20	1000	0.7	1000	100	150	50
	2N4407	75	225	1000	80	1500	30	1000	0.7	1000	100	150	50
	2N3245	55	165	500	50	1000	30	500	0.6	500	50	150	50
	2N3244	50	185	500	40	1000	50	500	0.5	500	50	175	50
	2N3467#	40	90	500	40	100	40	500	0.5	500	50	175	50
	2N3468#	40	90	500	50	1000	25	500	0.6	500	50	150	50
	2N3762#	43	115	1000	40	1500	30	1000	0.9	1000	100	180	50
	2N3763#	43	115	1000	60	1500	20	1000	0.9	1000	100	150	50
	2N4404	40	210	500	80	1000	30	500	0.5	500	50	200	50
	2N4405**	40	210	500	80	1000	50	500	0.5	500	50	200	50
	2N5022	40	90	500	—	500	25	1000	0.8	1000	100	170	50
	2N5023	40	90	500	—	500	40	1000	0.7	1000	100	200	50

*JAN available **JAN/JANTX available †JAN/JANTX/JANTXV/JANS available #JAN/JANTX/JANTXV available

TABLE 2. High-Gain Low-Noise Transistors

These transistors are characterized for high-gain and low-noise applications. Devices are listed in decreasing order of NF.

Package	Device Type	NF Wideband Typ* Max dB	$V_{(BR)CEO}$ Volts Min	I_C mA Max	h_{FE} Min	h_{FE} Max	@ I_C µA mA*	f_T MHz Min	@ I_C mA
NPN									
TO-18	2N2484#	8.0*	60	50	100	500	10	15	0.05
	2N930A	3.0	45	30	100	300	10	45	0.5
	2N930**	3.0	45	30	100	300	10	30	0.5
NPN DARLINGTON									
TO-18	MM6427		40	300	5000		10*	125	100
PNP									
TO-18	2N3962	10	60	200	100	450	1.0	40	0.5
	2N3963	10	80	200	100	450	1.0	40	0.5
	2N3965	8.0	60	200	250	600	1.0	50	0.5
	2N3964	4.0	45	200	250	600	1.0	50	0.5
	2N3798	3.5	60	50	150	450	500	30	0.5
	2N3799	2.5	60	50	300	900	500	30	0.5
TO-46	2N2604	4.0	45	0	40	120	0.01	30	0.5
	2N2605#	4.0	45	30	100	300	0.01	30	0.5

METAL SMALL-SIGNAL TRANSISTORS (continued)

TABLE 3. High-Frequency Amplifiers/Oscillators

The transistors shown are designed for use as both oscillators and amplifiers at UHF and VHF frequencies. Devices are listed in decreasing order of $V_{(BR)CEO}$ with each line.

Package	Device Type	$V_{(BR)CEO}$ Volts Min	h_{FE} Min @	I_C mA	G_{pe} dB Min	NF dB Max @	f MHz	f_T MHz Min @	I_C mA	C_{obo} pF Max
NPN										
TO-18	MM1941	20	25	10	7.0	—	—	600	10	2.5
TO-72	2N918†	15	20	3.0	15	6.0	60	600	4.0	1.7
PNP										
TO-18	2N3307	35	40	2.0	17	4.5	200	300	2.0	1.3
TO-72	2N4261#	15	30	10	—	—	—	1600	10	2.5
	2N4260	15	30	10	—	—	—	2000	10	2.5

*JAN available **JAN/JANTX available †JAN/JANTX/JANTXV/JANS available #JAN/JANTX/JANTXV available

TABLE 4. High-Voltage/High-Current Amplifiers

The following table lists Motorola standard devices that have high Collector-Emitter Breakdown Voltage. Devices are listed in decreasing order of $V_{(BR)CEO}$ within each package type.

Package	Device Type	$V_{(BR)CEO}$ Volts Min	I_C mA Max	h_{FE} Min @	I_C mA	$V_{CE(sat)}$ Volts Max @	I_C mA &	I_B mA	f_T MHz Min @	I_C mA
NPN										
TO-18	2N6431	300	50	50	30	0.5	20	2.0	50	10
	2N6430	200	50	50	30	0.5	20	2.0	50	10
TO-39	MM8520	500	1000	15	10	1.5	10	2.0	5.0	10
	2N3439#	350	1000	40	20	0.5	50	4	15	10
	MM421	325	1000	25	30	5.0	30	3	15	10
	2N3742	300	50	20	30	1.0	30	3.0	30	10
	2N5058	300	150	35	30	1.0	30	3.0	30	10
	MM420	250	1000	25	30	5.0	30	3	15	10
	2N3440#	250	1000	40	20	0.5	50	4	15	10
	MM3003	250	50	20	10				150	10
	2N4927	250	50	20	30	2.0	30	3.0	30	10
	2N5059	250	150	30	30	1.0	30	3.0	30	10
	MM3002	200	50	20	10				150	10
	2N4926	200	50	20	30	2.0	30	3.0	30	10
	MM3009	180	400	40	10				50	20
	MM3001	150	200	20	10				150	10
	2N3114	150	200	30	30	1.0	50	5.0	40	30
	2N3500#	150	300	40	150	0.4	150	15	150	20
	2N3501#	150	300	100	150	0.4	150	15	150	20
	2N3712	150	200	30	30	2.0	50	5.0	40	30
	2N5682	120	1000	40	250	0.6	250	25	30	100
	MM3008	120	400	40	10				50	20
	2N657	100		30	200	4.0	200	40		
	2N3498#	100	500	40	150	0.6	300	30	150	20
	2N3499#	100	500	100	150	0.6	300	30	150	20
	2N4924	100	200	40	150	0.4	50	5.0	100	20
	MM3007	100	2500	50	250	0.35	150	15	50	50
	2N5681	100	1000	40	250	0.6	250	25	30	100
	MM3006	80	2500	50	200	0.35	150	15	50	50
	2N4239	80	3000	30	250	0.3	500	50	2	100
	MM3005	60	2500	50	150	0.35	150	15	50	50
	2N656	60	—	30	200	4.0	200	40		
	2N4238	60	3000	30	250	0.3	500	50	2	100
	2N4237	40	3000	30	250	0.3	500	50	2	100

#JAN/JANTX/JANTXV available

METAL SMALL-SIGNAL TRANSISTORS (continued)

TABLE 4. High-Voltage High-Current Amplifiers (continued)

Package	Device Type	$V_{(BR)CEO}$ Volts Min	I_C mA Max	h_{FE} Min	@ I_C mA	$V_{CE(sat)}$ Volts Max	@ I_C mA	& I_B mA	f_T MHz Min	@ I_C mA
PNP										
TO-18	2N6433	300	1000	30	30	0.5	20	2.0	50	10
	2N6432	200	1000	30	30	0.5	20	2.0	50	10
	2N3497	120	100	40	10	0.35	10	1.0	150	20
	2N3496	80	100	40	10	0.3	10	1.0	200	20
TO-39	2N3743#	300	50	25	30	8.0	30	3.0	30	10
	•2N5416#	300	1000	30	50	2.5	50	5	15	10
	MM4003	250	500	20	10	5.0	10	1.0	—	—
	2N4931#	250	500	20	20	5.0	10	1.0	20	20
	MM4002	200	500	20	10	5.0	10	1.0	—	—
	2N4930#	200	500	20	20	5.0	10	1.0	20	20
	•2N5415#	200	1000	30	50	2.5	50	5	15	10
	2N3637#	175	1000	100	50	0.5	50	5.0	200	30
	2N3636#	175	1000	50	50	0.5	50	5.0	150	30
	2N4929	150	500	25	10	0.5	10	1.0	100	20
	MM4001	150	500	20	10	0.6	10	1.0	—	—
	2N3635#	140	1000	100	50	0.5	50	5.0	200	30
	2N3634#	140	1000	50	50	0.5	50	5.0	150	30
	2N3495	120	100	40	10	0.35	10	1.0	150	20
	2N5680	120	1000	40	250	0.6	250	25	30	100
	MM4000	100	100	20	10	0.6	10	1.0	—	—
	MM5007	100	2000	50	250	0.5	150	15	30	50
	2N4928	100	100	25	10	0.5	10	1.0	100	20
	2N5679	100	1000	40	250	0.6	250	25	30	100
	MM5006	80	2000	50	200	0.5	150	15	30	50
	2N3494	80	100	40	10	0.3	10	1.0	200	20
	2N4236	80	3000	30	250	0.6	1000	125	3	100
	2N4036	65	1000	40	150	0.65	150	15	60	50
	MM5005	60	2000	50	150	0.5	150	15	30	50
	2N4235	60	3000	30	250	0.6	1000	125	3	100
	2N4234	40	3000	30	250	0.6	1000	125	3	100

#JAN/JANTX/JANTXV available

TABLE 5. General-Purpose Amplifiers

These transistors are designed for dc to VHF amplifier applications, general-purpose switching applications, and complementary circuitry. Devices are listed in decreasing order of $V_{(BR)CEO}$ within each package group.

Package	Device Type	$V_{(BR)CEO}$ Volts Min	f_T MHz Min	@ I_C mA	I_C mA Max	h_{FE} Min	h_{FE} Max	@ I_C mA
NPN								
TO-18	2N2896	90	120	50	1000	60	200	150
	2N3700#	80	80	1.0	1000	50		500
	2N2895	65	120	50	1000	40	120	150
	2N956	50	70	50		40	120	150
	2N2897	45	100	50	1000	50	200	150
	2N718	40	50	50		40	120	150
	2N2221A#	40	250	20	800	40	120	150
	2N2222A#	40	300	20	800	100	300	150
	2N3946	40	300	10	200	50	150	10
	2N3947	40	300	10	200	100	300	10
	2N2222#	30	250	20	800	100	300	150
	2N3302	30	250	50	500	100	300	150
	2N916*	25	300	10		50	200	10
TO-39	2N1711	80	70	50		100	300	150
	2N3019#	80	100	50	1000	100	300	150
	2N3020	80	80	50	1000	40	120	150
	2N1613#	50	60	50	500	40	120	150
	2N2193A	50	50	50	1000	40	120	150
	2N2270	45	100	50	1000	50	200	150

TABLE 5. General-Purpose Amplifiers (continued)

Package	Device Type	$V_{(BR)CEO}$ Volts Min	f_T MHz Min	@ I_C mA	I_C mA Max	h_{FE} Min	h_{FE} Max	@ I_C mA
NPN								
TO-39	2N697	40	50	50		40	120	150
	2N2218A#	40	250	20	800	40	120	150
	2N2219A#	40	300	20	800	100	300	150
	2N3053	40	100	50	700	50	250	150
	2N2218#	30	250	20	800	40	120	150
	2N2219#	30	250	20	800	100	300	150
	2N3300	30	250	50	500	100	300	150
TO-46	2N5581**	40	250	20	800	40	120	150
	2N5582**	40	300	20	800	100	300	150
TO-52	MM3903	40	250	10	200	50	150	10
	MM3904	40	300	10	200	100	300	10
PNP								
TO-18	2N4026	80	100	50	1000	15	—	100
	2N4027	80	100	50	1000	10	—	100
	2N4028	80	150	50	1000	40	—	100
	2N4029	80	150	50	1000	25	—	100
	2N2906A#	60	200	50	600	40	120	150
	2N2907A†	60	200	50	600	100	300	150
	2N3250A#	60	250	10	200	50	150	10
	2N3251A#	60	300	10	200	100	300	10
	2N2906#	40	200	50	600	40	120	150
	2N2907#	40	200	50	600	100	300	150
	2N3250	40	250	10	200	50	150	10
	2N3251	40	300	10	200	100	300	10
	2N869	18						
TO-39	MM5007	100	30	50	2000	50	250	250
	MM5006	80	30	50	2000	50	250	200
	2N4031	80	100	50	1000	10	—	100
	2N4033#	80	150	50	1000	25	—	100
	2N4404	80	200	50	1000	40	120	150
	2N4405**	80	200	50	1000	100	300	150
	MM4036	65	60	50	1000	20	140	150
	2N4036	65	60	50	1000	40	140	150
	2N4037	65	60	50	1000	40	—	150
	MM5005	60	30	50	2000	50	250	150
	2N2904A#	60	200	50	600	40	120	150
	2N2905A†	60	200	50	600	100	300	150
	2N4030	60	100	50	1000	15	—	100
	2N4032	60	150	50	1000	40	—	100
	MM4037	40	60	50	1000	50	250	150
	2N1131A	40	50	50	600	30	90	150
	2N1132A	40	60	50	600	30	90	150
	2N2904#	40	200	50	600	40	120	150
	2N2905#	40	200	50	600	100	300	150
	2N1132*	35	60	50	600	30	90	150
TO-46	2N3485A**	60	200	50	600	40	120	150
	2N3486A**	60	200	50	600	100	300	150
	2N3673	50	200	50	600	75	225	150
	2N3486	40	200	50	600	100	300	150
TO-52	MM3906	40	250	10	200	100	300	10
	MM3905	40	200	10	200	50	150	10

*JAN available **JAN/JANTX available #JAN/JANTX/JANTXV available

METAL SMALL-SIGNAL TRANSISTORS (continued)

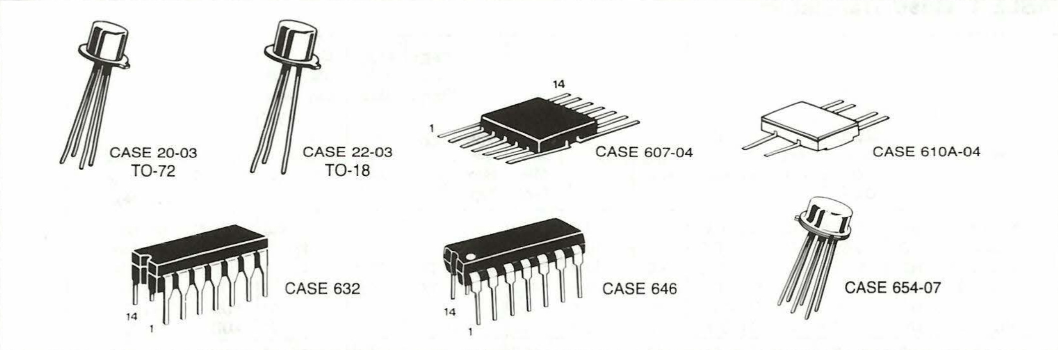
TABLE 6. Choppers

Devices are listed in decreasing $V_{(BR)EBO}$.

Package	Device	$V_{(BR)EBO}$ Min	$V_{(BR)ECO}$	Min $h_{FE(inv)}$	Offset Voltage $V_{EC(ofs)}$ Max (mV)	On-State Resistance $r_{ec(on)}$ Max (Ω)
TO-46	2N2946	40	35	3.0	2.0	45
	2N2946A	40	35	20	2.0	8.0
	2N5230	30	20	15	0.5	8.0
	2N5231	30	20	15	0.8	10
	2N2945A	25	20	30	1.0	6.0
	2N2945	25	20	4.0	1.0	35
	2N5229	15	10	15	0.5	6.0

JAN/JANTX available

Multiple Small-Signal Transistors



The trend in electronic system design is toward the use of integrated circuits — to reduce component cost, assembly cost, and equipment cost. But ICs still aren't all things to all people, and for those circuit designs where ICs are not available, there is a noticeable swing towards the use of multiple devices.*

Motorola is reacting to this expanding market requirement by making available a large selection of Quad, Dual, and Darlington transistors for off-the-shelf delivery. The chips used in the Quad and Dual transistors are those that have emerged as the most popular ones for discrete transistor applications. But even beyond that, Motorola offers its entire vast repertoire of discrete small-signal transistors for multiple-device packaging. For special applications where the devices in this brochure might not quite fit the design requirements, special configurations can be supplied with quick turnaround time and at low premiums.

**Multiple devices, as described here, encompass two or more transistor chips in a single package. Included in this definition are the Darlington transistors which consist of two interconnected devices functioning as a single-stage amplifier.*

Specification Tables

The following short form specifications include Quad and Dual transistors listed in alphanumeric order. Some columns denote two different types of data indicated by either **bold** or *italic* typeface. See key and headings for proper identification.

KEY

TYPE NO.	ID	P_D Watts One Die Only	Ref Point	V_{CE-} Volts	Subscript	I_C Amp Max	h_{FE} Min	@ I_C	Unit	f_T MHz Min	C_{ob} pF Max	h_{FE1}/h_{FE2} ······ *t_{on} ns Max*	ΔV_{BE} mV Max ······ *t_{off} ns Max*	**Gp dB Min** ······ *$V_{CE(sat)}$ @ Volts Max*	**NF dB Max** ······ *I_C/I_B*	**@ f** ······ *& I_C*	Unit	PACKAGE TO- No.	Case No.

Alphanumeric listing type numbers

Identification Code
1st Letter: Polarity
C – both types in multiple device
N – NPN
P – PNP
2nd Letter; Use
A – General Purpose Amplifier
E – Low Noise Audio Amplifier
F – Low Noise RF Amplifier
G – General Purpose Amplifier and Switch
H – Tuned RF/IF Amplifier
M – Differential Amplifier
S – High Speed Switch

Power Dissipation specified at 25°C. Single die rating.
Ref. Point: A · Ambient temperature
C · Case temperature

Rated Minimum Collector-Emitter Voltage
Subscript letter identifies base termination listed below in order of preference.
SUBSCRIPT
O – V_{CEO}, open

Continuous (DC) Collector Current

Common-emitter DC Current Gain

Units for test current
A – ampere
m – mA
u – μA

Current Gain-Bandwidth Product

Output Capacitance, common-base. Shown without distinction.
C_{cb} – Collector-Base Capacitance
C_{re} – Common-Emitter Reverse Transfer Capacitance

h_{FE1}/h_{FE2} – Current Gain Ratio
V_{BE} – Differential Base Voltage $|V_{BE1} - V_{BE2}|$.
Differential Amplifiers
t_{on} – turn-on time
t_{off} – turn-off time

G_p – Power Gain
NF – Noise Figure
f – Test Frequency
AUD – 10-15k Hz
Frequency Units:
H · Hertz
K · kHz
M · MHz
G · GHz
$V_{CE(sat)}$ – Collector-Emitter Saturation Voltage
I_C – Test Current
Current Units
u – μA
m – mA
A – Amp

JEDEC Outline/Motorola Package Outline.

MULTIPLE SMALL-SIGNAL TRANSISTORS (continued)

TABLE 1. Quad Transistors

TYPE NO.	ID	P_D Watts One Die Only	Ref. Point	V_{CE}- Volts	Subscript	I_C Amp Max	h_{FE} Min	@ I_C	Unit	f_T MHz Min Typ*	C_{ob} pF Max Typ*	h_{FE1}/h_{FE2} — t_{on} ns Max Typ*	ΔV_{BE} mV Max — t_{off} ns Max Typ*	Gp dB Min — V_{CE} (sat) Volts Max	NF dB Max Typ* — @ I_C/I_B	f — I_C	Unit	PACKAGE TO-No.	PACKAGE Case No.
MHQ918	NF	0.65	A	15	O	0.05	20	3.0	m	600	2.0				6.0	60	M	116	632
MHQ2221	NG	0.65	A	40	O	0.5	40	150	m	200	8.0			.4		150	m	116	632
MHQ2222†	NG	0.65	A	40	O	0.5	100	150	m	200	8.0	25*	250*	.4	10	150	m	116	632
MHQ2369	NS	0.5	A	15	O	0.5	40	10	m	450	4.0	9.0*	15*	.25	10	10	m	116	632
MHQ2483	NA	0.6	A	40	O	0.05	150	1.0	m	50					3*	AUD		116	632
MHQ2484	NA	0.6	A	40	O	0.05	300	1.0	m	50					2*	AUD		116	632
MHQ2906	PG	0.65	A	40	O	0.6	40	150	m	200	8.0	30*	100*	.4	10	150	m	116	632
MHQ2907†	PG	0.65	A	40	O	0.6	100	150	m	200	8.0	30*	100*	.4	10	150	m	116	632
MHQ3467†	PS	0.9	A	40	O	1.0	20	500	m	125	25	40	90	.5	10	500	m	116	632
MHQ3546	PS	0.5	A	12	O	0.2	30	10	m	600	6.0	.15*	25*	.25	10	10	m	116	632
MHQ3798	PA	0.5	A	40	O	0.05	150	0.1	m	60	4.0				3*	AUD		116	632
MHQ3799	PA	0.5	A	60	O	0.05	300	0.1	m	60	4.0				2*	AUD		116	632
MHQ4001A	NS	0.75	A	40	O	1.5	30	500	m	200	10	40	75	.52	10	500	m	116	632
MHQ4002A	NS	0.75	A	45	O	1.5	30	500	m	200	10	40	75	.52	10	500	m	116	632
MHQ4013††	NS	0.75	A	40	O	1.5	35	500	m	200	10	35	60	.52	10	500	m	116	632
MHQ4014	NS	0.75	A	45	O	1.5	35	500	m	200	10	35	60	.52	10	500	m	116	632
MHQ6001	CA	0.65	A	30	O	0.5	40	150	m	200	8.0	30*	225*	.4	10	150	m	116	632
MHQ6002	CA	0.65	A	30	O	0.5	100	150	m	200	8.0	30*	225*	.4	10	150	m	116	632
MHQ6100	CA	0.5	A	40	O	0.05	75	1.0	m	175*	4.5*			.25		1.0	m	116	632
MPQ918	NA	0.625	A	15	O	0.05	20	3.0	m	600	1.7				6.0	60	M		646
MPQ1000	NA	0.65	A	20	O	0.5	50	10	m	175	8.0			0.5	10	150	m		646
MPQ2221	NA	0.65	A	30	O	0.5	40	150	m	200	8.0	25*	250*	.4	10	150	m		646
MPQ2221A	NA	0.65	A	30	O	0.5	40	150	m	200	8.0	25*	250*	.4	10	150	m		646
MPQ2222	NA	0.65	A	30	O	0.5	100	150	m	200	8.0	25*	250*	.4	10	150	m		646
MPQ2222A	NA	0.65	A	30	O	0.5	100	150	m	200	8.0	25*	250*	.4	10	150	m		646
MPQ2369	NS	0.5	A	15	O	0.5	40	10	m	450	4.0	9.0*	15*	.25	10	10	m		646
MPQ2483	NA	0.625	A	40	O	0.05	150	1.0	m	50					3*	AUD			646
MPQ2484	NA	0.625	A	40	O	0.05	300	1.0	m	50					2*	AUD			646
MPQ2906	PA	0.65	A	40	O	0.6	40	150	m	200	8.0	30*	100*	.4	10	150	m		646
MPQ2906A	PA	0.65	A	60	O	0.6	40	150	m	200	8.0	30*	100*	.4	10	150	m		646
MPQ2907	PA	0.65	A	40	O	0.6	100	150	m	200	8.0	30*	100*	.4	10	150	m		646
MPQ2907A	PA	0.65	A	60	O	0.6	100	150	m	200	8.0	30*	100*	.4	10	150	m		646
MPQ3303	NS	0.65	A	12	O	1.0	40	300	m	400	10	15	25	0.7	10	1.0	A		646
MPQ3467	PS	0.75	A	40	O	1.0	20	500	m	125	25	40	90	0.5	10	500	m		646
MPQ3546	PA	0.5	A	12	O	0.2	30	10	m	600	6.0	15*	25*	.25	10	10	m		646
MPQ3725†	NS	1.0	A	40	O	1.0	25	500	m	250	10	35	60	.45	10	500	m		646
MPQ3725A	NS	1.0	A	50	O	1.0	30	500	m	200	10	3.5	60	.45		500	m		646
MPQ3762	PS	0.75	A	40	O	1.5	35	150	m	150	15	50	120	.55	10	500	m		646
MPQ3798	PA	0.625	A	40	O	0.05	150	0.1	m	60	4.0				3*	AUD			646
MPQ3799	PA	0.625	A	60	O	0.05	300	0.1	m	60	4.0				2*	AUD			646
MPQ3904	NG	0.50	A	40	O	0.2	75	10	m	250	4.0	37*	136*	0.2	10	10	m		646
MPQ3906	PG	0.50	A	40	O	0.2	75	10	m	200	4.5	43*	155*	.25	10	10	m		646

† H, HX, and HXV Suffixes also available.
†† MHQ4013 is electrically equivalent to MHQ3725.

TABLE 1. Quad Transistors (continued)

TYPE NO.	ID	P_D Watts One Die Only / Ref. Point	V_{CE}- Volts / Subscript	I_C Amp Max	h_{FE} Min	@ I_C / Unit	f_T MHz Min Typ*	C_{ob} pF Max Typ*	h_{FE1}/h_{FE2} ----- _t_{on} ns Max Typ*_	ΔV_{BE} mV Max ----- _t_{off} ns Max Typ*_	Gp dB Min ----- _V_{CE} (sat) Volts Max_	NF dB Max Typ* ----- @ _I_C/I_B_	@ f & _I_C_ / Unit	PACKAGE TO- No.	PACKAGE Case No.
MPQ6001	CG	0.65 A	30 O	0.5	40	150 m	200	8.0	_30*_	_225*_	_0.4_	_10_	_150 m_		646
MPQ6002	CG	0.65 A	30 O	0.5	100	150 m	200	8.0	_30*_	_225*_	_0.4_	_10_	_150 m_		646
MPQ6100	CA	0.5 A	40 O	0.05	75	1.0 m	50	4.0				__4*__	__AUD__		646
MPQ6100A	CA	0.5 A	45 O	0.05	150	1.0 m	50	4.0				__4*__	__AUD__		646
MPQ6501	CG	0.65 A	30 O	0.5	40	150 m	200	8.0	_30*_	_225*_	_0.4_	_10_	_150 m_		646
MPQ6502	CG	0.65 A	30 O	0.5	100	150 m	200	8.0	_30*_	_225*_	_0.4_	_10_	_150 m_		646
MPQ6600	CA	0.5 A	40 O	0.05	75	1.0 m	50	4.0				__4*__	__AUD__		646
MPQ6600A	CA	0.5 A	45 O	0.05	150	1.0 m	50	4.0			_0.25_	_4.0_	_1.0 m_		646
MPQ6700	CA	0.5 A	40 O	0.2	70	10 m	200	4.5			_0.25_	_4.0_	_1.0 m_		646
MPQ6842	CA	0.75 A	40 O	0.5	70	10 m	300	4.5	_45_	_150_	_0.15_	_10_	_0.5 m_		646
MPQ7041	NA	0.75 A	150 O	0.5	25	1.0 m	50	5.0			_0.5_	_10_	_20 m_		646
MPQ7042	NA	0.75 A	200 O	0.5	25	1.0 m	50	5.0			_0.5_	_10_	_20 m_		646
MPQ7043	NA	0.75 A	250 O	0.5	25	1.0 m	50	5.0			_0.5_	_10_	_20 m_		646
MPQ7051	CA	0.75 A	150 O	0.5	25	1.0 m	50	5.0			_0.7_	_10_	_20 m_		646
MPQ7052	CA	0.75 A	200 O	0.5	25	1.0 m	50	5.0			_0.7_	_10_	_20 m_		646
MPQ7053	CA	0.75 A	250 O	0.5	25	1.0 m	50	5.0			_0.7_	_10_	_20 m_		646
MPQ7091	PA	0.75 A	150 O	0.5	25	1.0 m	50	5.0			_0.5_	_10_	_20 m_		646
MPQ7092	PA	0.75 A	200 O	0.5	25	1.0 m	50	5.0			_0.5_	_10_	_20 m_		646
MPQ7093	PA	0.75 A	250 O	0.5	35	10 m	50	5.0			_0.5_	_10_	_20 m_		646
MQ918	NA	0.55 A	15 O	0.05	50	3.0 m	600	1.7				__6.0__	__60 M__		607
MQ930	NA	0.4 A	45 O	0.03	150	1.0 m	260*	6.0							607
MQ982	PA	0.4 A	50 O	0.6	40	150 m	200	8.0			_0.5_	_10_	_150 m_		607
MQ1120	PA	0.4 A	30 O	0.5	50	10 m	200	8.0			_0.10_	_10_	_10 m_		607
MQ1129	NA	0.4 A	30 O	0.5	100	10 m	200	8.0			_0.15_	_10_	_10 m_		607
MQ2218	NA	0.4 A	30 O	0.5	40	150 m	200	8.0			_0.4_	_10_	_150 m_		607
MQ2218A	NA	0.6 A	40 O	0.5	40	150 m	200	8.0			_0.4_	_10_	_150 m_		607
MQ2219	NA	0.6 A	30 O	0.5	100	150 m	200	8.0			_0.3_	_10_	_150 m_		607
MQ2219A	NA	0.4 A	30 O	0.5	100	150 m	200	8.0			_0.3_	_10_	_150 m_		607
MQ2369	NS	0.40 A	15 O	0.5	40	10 m	500	4.0	_15_	_20_	_.25_	_10_	_10 m_		607
MQ2484	NE	0.4 A	60 O	0.03	100	10 u	260*	6.0				__3.0__	__AUD__		607
MQ2904	PG	0.4 A	40 O	0.6	40	150 m	300	8.0	_42_	_130_	_.4_	_10_	_150 m_		607
MQ2905A	PG	0.4 A	60 O	0.6	100	150 m	300	8.0	_42_	_130_	_.4_	_10_	_150 m_		607
MQ3251	PA	0.40 A	40 O	0.05	100	10 m	300	6.0			_.25_	_10_	_10 m_		607
MQ3467	PS	0.40 A	40 O	1.0	20	500 m	150	20	_40_	_110_	_0.5_	_10_	_500 m_		607
MQ3725	NS	0.40 A	40 O	1.0	50	100 m	200	10	_45_	_75_	_.26_	_10_	_100 m_		607
MQ3762	PS	0.40 A	40 O	1.5	20	1.0 A	150	20	_40_	_110_	_1.0_	_10_	_1.0 A_		607
MQ3798	PA	0.40 A	60 O	0.05	150	100 u	450*	4.0			_0.2_	_10_	_1.0 m_		607
MQ3799	PA	0.40 A	60 O	0.05	300	100 u	450*	4.0			_0.2_	_10_	_1.0 m_		607
MQ3799A	PM	0.40 A	60 O	0.05	300	100 u	450*	4.0	__0.9__	__3.0__	_0.2_	_10_	_1.0 m_		607
MQ6001	CG	0.40 A	30 O	0.5	40	150 m	200	8.0	_60_	_350_	_0.4_	_10_	_150 m_		607
MQ6002	CG	0.40 A	30 O	0.5	100	150 m	200	8.0	_60_	_350_	_0.4_	_10_	_150 m_		607
MQ7001	PA	0.4 A	30 O	0.6	70	1.0 m	200	8.0			_0.4_	_10_	_150 m_		607
MQ7003	NA	0.40 A	40 O	0.05	50	10 m	200	6.0			_.35_	_10_	_1.0 m_		607
MQ7004	NA	0.40 A	13 O	0.2	30	10 m	675*	4.0			_0.4_	_10_	_10 m_		607
MQ7005	NA	0.4 A	12 O	0.05	30	3.0 m	400	3.0			_1.0_		_10 m_		607
MQ7007	PA	0.4 A	40 O	0.2	30	1.0 m	300	8.0			_1.0_	_10_	_50 m_		607
MQ7021	CG	0.40 A	40 O	0.05	50	10 m	200	6.0	_28*_	_72*_	_.35_	_10_	_10 m_		607
2N5146	PA	0.4 A	40 O	1.5	20	1.0 A	150	20	_40_	_110_	_1.0_	_10_	_1.0 A_		607
2N6501	NS	0.6 A	40 O	1.0	50	100 m	250	10	_35_	_60_	_0.3_	_10_	_100 m_		607

Some columns show 2 different types of data indicated by either **bold** *or italic typefaces. See key and headings.*

TABLE 2. QUAD TMOS FETS (N CHANNEL)

Device	$r_{ds(on)}$ (Ω) Max	@ I_D (μA)	$V_{GS(t/h)}$ (V) Min	$V_{GS(t/h)}$ (V) Max	@ V_{DS} (V)	@ I_D (mA)	I_{DSS} (μA) Max	@ V_{DS} (V)	$V_{(BR)DSS}$ (V) Min	@ I_G (μA)	I_{GSS} (nA) Max	@ V_{DG} (V)	C_{iss} (pF) Max	@ V_{DS} (V)	C_{rss} (pF) Max	@ V_{DS} (V)	t_{on} (ns) Max	t_{off} (ns) Max
MFQ930C	1.4	1.0A	1.0	3.5	V_{GS}	1.0	10	35	35	10	50	15	70	25	18	25	15	15
MFQ960C	1.7	1.0A	1.0	3.5	V_{GS}	1.0	10	60	60	10	50	15	70	25	18	25	15	15
MFQ990C	2.0	1.0A	1.0	3.5	V_{GS}	1.0	10	90	90	10	50	15	70	25	18	25	15	15

MULTIPLE SMALL-SIGNAL TRANSISTORS (continued)

TABLE 3. Dual Transistors

TYPE NO.	ID	P_D Watts One Die Only	Ref. Point	V_{CE}- Volts	Subscript	I_C Amp Max	h_{FE} Min	@ I_C	Unit	f_T MHz Min	C_{ob} pF Max	**h_{FE1}/h_{FE2}** / *t_{on} ns Max*	**ΔV_{BE} mV Max** / *t_{off} ns Max*	**Gp dB Min** / *V_{CE}(sat) Volts Max*	**NF dB Max** / *@ I_C/I_B*	**@ f** / *& I_C*	Unit	PACKAGE TO- No.	Case No.
MD708	NG	0.55	A	15	O	0.2	40	10	m	300	5.0	*35*	*75*	*.20*	*10*	*10*	*m*		654
MD708A	NM	0.55	A	15	O	0.2	40	10	m	300	5.0	**0.9**	**5.0**	*.20*	*10*	*10*	*m*		654
MD708AF	NM	0.35	A	15	O	0.2	40	10	m	300	5.0	**0.9**	**5.0**	*.20*	*10*	*10*	*m*		610A
MD708B	NM	0.55	A	15	O	0.2	40	10	m	300	5.0	**0.8**	**10**	*.20*	*10*	*10*	*m*		654
MD708BF	NM	0.35	A	15	O	0.2	40	10	m	300	5.0	**0.8**	**10**	*.20*	*10*	*10*	*m*		610A
MD708F	NG	0.35	A	15	O	0.2	40	10	m	300	5.0	*35*	*75*	*.20*	*10*	*10*	*m*		610A
MD918	NF	0.55	A	15	O	0.05	50	3.0	m	600	1.7				**6.0**	**60**	**M**		654
MD918A	NM	0.55	A	15	O	0.05	50	3.0	m	600	1.7	**0.9**	**5.0**		**6.0**	**60**	**M**		654
MD918AF	NM	0.35	A	15	O	0.05	50	3.0	m	600	1.7	**0.9**	**5.0**		**6.0**	**60**	**M**		610A
MD918B	NM	0.55	A	15	O	0.05	50	3.0	m	600	1.7	**0.8**	**10**		**6.0**	**60**	**M**		654
MD918F,BF	NF	0.35	A	15	O	0.05	50	3.0	m	600	1.7				**6.0**	**60**	**M**		610A
MD982,F	PA	0.40	A	50	O	0.6	40	150	m	200	8.0			*0.5*	*10*	*150*	*m*		610A
MD984	PA	.575	A	20	O	0.2	25	10	m	250				*0.5*	*10*	*50*	*m*		654
MD985	CA	.575	A	30	O	0.5	40	150	m	200	8.0			*0.5*	*10*	*150*	*m*		654
MD985F	CA	0.35	A	30	O	0.5	40	150	m	200	8.0			*0.5*	*10*	*150*	*m*		610A
MD986	CA	0.55	A	15	O	0.2	25	10	m	200	4.0			*0.3*	*10*	*10*	*m*		654
MD986F	CA	0.35	A	15	O	0.2	25	10	m	200	4.0			*0.3*	*10*	*10*	*m*		610A
MD1120	NM	0.575	A	30	O	0.5	50	10	m	200	8.0	**0.8**	**10**	*.10*	*10*	*10*	*m*		654
MD1120F	NM	0.35	A	30	O	0.5	50	10	m	200	8.0	**0.8**	**10**	*.10*	*10*	*10*	*m*		610A
MD1121	NM	0.575	A	30	O	0.5	50	10	m	200	8.0	**0.9**	**10**	*.10*	*10*	*10*	*m*		654
MD1121F	NM	0.35	A	30	O	0.5	50	10	m	200	8.0	**0.9**	**10**	*.10*	*10*	*10*	*m*		654
MD1122	NM	0.575	A	30	O	0.5	50	10	m	200	8.0	**0.9**	**5.0**	*.10*	*10*	*10*	*m*		654
MD1122F	NM	0.35	A	30	O	0.5	50	20	m	200	8.0	**0.9**	**5.0**	*.10*	*10*	*10*	*m*		654
MD1123	PM	0.575	A	40	O	0.2	30	100	u	250	4.0	**0.8**	**10**	*.25*	*10*	*10*	*m*		654
MD1129	NM	0.575	A	30	O	0.5	100	10	m	200	8.0	**0.9**	**5.0**	*0.1*	*10*	*10*	*m*		654
MD1129F	NM	0.35	A	30	O	0.5	100	10	m	200	8.0	**0.9**	**5.0**	*.15*	*10*	*10*	*m*		610A
MD1130	PM	0.575	A	40	O	0.2	100	100	u	200	4.0	**0.9**	**5.0**	*.25*	*10*	*10*	*m*		654
MD1130F	PM	0.35	A	40	O	0.2	100	100	u	200	4.0	**0.9**	**5.0**	*.25*	*10*	*10*	*m*		610A
MD1132	NM	0.3	A	15	O	0.05	50	1.0	m	600	1.7	**0.9**	**5.0**	*0.4*	*10*	*10*	*m*		654
MD2060F	NM	0.35	A	60	O	0.5	30	0.1	m	100	15	**0.9**	**5.0**	*.10*	*8.0*	*10*	*m*		654
MD2218	NG	0.575	A	30	O	0.5	40	150	m	200	8.0	*60*	*350*	*0.4*	*10*	*150*	*m*		654
MD2218A	NG	0.575	A	30	O	0.5	40	150	m	200	8.0	*45*	*310*	*0.3*	*10*	*150*	*m*		654
MD2218AF	NG	0.35	A	30	O	0.5	40	150	m	200	8.0	*45*	*310*	*0.3*	*10*	*150*	*m*		610A
MD2218F	NG	0.35	A	30	O	0.5	40	150	m	200	8.0	*60*	*350*	*0.4*	*10*	*150*	*m*		610A
MD2219	NG	0.575	A	30	O	0.5	100	150	m	200	8.0	*60*	*350*	*0.4*	*10*	*150*	*m*		654
MD2219A	NG	0.575	A	30	O	0.5	100	150	m	200	8.0	*45*	*310*	*0.3*	*10*	*150*	*m*		654
MD2219AF	NG	0.350	A	30	O	0.5	100	150	m	200	8.0	*45*	*310*	*0.3*	*10*	*150*	*m*		610A
MD2219F	NG	0.350	A	30	O	0.5	100	150	m	200	8.0	*60*	*350*	*0.4*	*10*	*150*	*m*		610A
MD2369	NS	0.55	A	15	O	0.5	40	10	m	500	4.0	*15*	*20*	*.25*	*10*	*10*	*m*		654
MD2369A	NM	0.55	A	15	O	0.5	40	10	m	500	4.0	**0.9**	**5.0**	*.25*	*10*	*10*	*m*		654
MD2369AF	NM	0.35	A	15	O	0.5	40	10	m	500	4.0	**0.9**	**5.0**	*.25*	*10*	*10*	*m*		610A
MD2369B	NM	0.55	A	15	O	0.5	40	10	m	500	4.0	**0.8**	**10**	*.25*	*10*	*10*	*m*		654
MD2369BF	NM	0.35	A	15	O	0.5	40	10	m	500	4.0	**0.8**	**10**	*.25*	*10*	*10*	*m*		610A
MD2369F	NS	0.35	A	15	O	0.5	40	10	m	500	4.0	*15*	*20*	*.25*	*10*	*10*	*m*		610A
MD2904	PG	0.575	A	40	O	0.6	40	150	m	200	8.0	*45*	*130*	*0.4*	*10*	*150*	*m*		654
MD2904A	PG	0.575	A	60	O	0.6	40	150	m	200	8.0	*45*	*130*	*0.4*	*10*	*150*	*m*		654
MD2904AF	PG	0.350	A	60	O	0.6	40	150	m	200	8.0	*45*	*130*	*0.4*	*10*	*150*	*m*		610A
MD2904F	PG	0.350	A	40	O	0.6	40	150	m	200	8.0	*45*	*130*	*0.4*	*10*	*150*	*m*		610A
MD2905	PG	0.575	A	40	O	0.6	100	150	m	200	8.0	*45*	*130*	*0.4*	*10*	*150*	*m*		654

Some columns show 2 different types of data indicated by either **bold** *or italic typefaces. See key and headings.*

MULTIPLE SMALL-SIGNAL TRANSISTORS (continued)

TABLE 3. Dual Transistors (continued)

TYPE NO.	ID	P_D Watts One Die Only	Ref. Point	V_{CE-} Volts	Subscript	I_C Amp Max	h_{FE} Min	@ I_C Unit	f_T MHz Min Typ*	C_{ob} pF Max	**h_{FE1}/h_{FE2}** / *t_{on} ns Max*	**ΔV_{BE} mV Max** / *t_{off} ns Max*	**Gp dB Min** / *V_{CE} (sat) @ — Volts Max*	**NF dB Max** / *I_C/I_B*	**@ f** / *& I_C* Unit	PACKAGE TO- No.	PACKAGE Case No.
MD2905A	PG	0.575	A	60	O	0.6	100	150 m	200	8.0	*45*	*130*	*0.4*	*10*	*150 m*		654
MD2905AF	PG	0.35	A	60	O	0.6	100	150 m	200	8.0	*45*	*130*	*0.4*	*10*	*150 m*		610A
MD2905F	PG	0.35	A	40	O	0.6	100	150 m	200	8.0	*45*	*130*	*0.4*	*10*	*150 m*		610A
MD3250	PA	0.57	5	A40	O	0.20	50	1.0 m	200	6.0			*.25*	*10*	*10 m*		654
MD3250A	PM	0.57	5	A40	O	0.20	50	1.0 m	200	6.0	**0.9**	**5.0**	*.25*	*10*	*10 m*		654
MD3250AF	PM	0.35	A	40	O	0.20	50	1.0 m	200	6.0	**0.9**	**5.0**	*.25*	*10*	*10 m*		610A
MD3250F	PA	0.35	A	40	O	0.20	50	1.0 m	200	6.0			*.25*	*10*	*10 m*		610A
MD3251	PA	0.575	A	40	O	0.20	100	1.0 m	250	6.0			*.25*	*10*	*10 m*		654
MD3251A	PM	0.575	A	40	O	0.20	100	1.0 m	250	6.0	**0.9**	**5.0**	*.25*	*10*	*10 m*		654
MD3251AF	PM	0.35	A	40	O	0.20	100	1.0 m	250	6.0	**0.9**	**5.0**	*.25*	*10*	*10 m*		610A
MD3251F	PA	0.35	A	40	O	0.20	100	1.0 m	250	6.0			*.25*	*10*	*10 m*		610A
MD3409	NM	0.575	A	30	O	0.5	50	10 m	200	8.0	**0.8**	**10**	*.15*	*10*	*10 m*		654
MD3410	NM	0.575	A	30	O	0.5	50	10 m	200	8.0	**0.9**	**10**	*.15*	*10*	*10 m*		654
MD3467	PS	0.60	A	40	O	1.5	20	500 m	150	20	*40*	*110*	*0.5*	*10*	*500 m*		654
MD3467F	PS	0.35	A	40	O	1.5	20	500 m	150	20	*40*	*110*	*0.5*	*10*	*500 m*		610A
MD3725	NS	0.60	A	40	O	1.0	50	100 m	200	10	*45*	*75*	*.26*	*10*	*100 m*		654
MD3725F	NS	0.35	A	40	O	1.0	50	100 m	200	10	*45*	*75*	*.26*	*10*	*100 m*		610A
MD3762	PS	0.60	A	40	O	1.5	20	1.0 A	150	20	*40*	*110*	*1.0*	*10*	*1.0 A*		654
MD3762F	PS	0.35	A	40	O	1.5	20	1.0 A	150	20	*40*	*110*	*1.0*	*10*	*1.0 A*		610A
MD5000	PH	0.3	A	15	O	0.05	20	3.0 m	600	1.7			**15**		**200 M**		654
MD5000A	PM	0.3	A	15	O	0.05	20	3.0 m	600	1.7	**0.9**	**5.0**	**15**		**200 M**		654
MD5000B	PM	0.3	A	15	O	0.05	20	3.0 m	600	1.7	**0.8**	**10**	**15**		**200 M**		654
MD6001	CG	.575	A	30	O	0.5	40	150 m	200	8.0	*60*	*350*	*0.4*	*10*	*150 m*		654
MD6001F	CG	0.35	A	30	O	0.5	40	150 m	200	8.0	*60*	*350*	*0.4*	*10*	*150 m*		610A
MD6002	CG	.575	A	30	O	0.5	100	150 m	200	8.0	*60*	*350*	*0.4*	*10*	*150 m*		654
MD6002F	CG	0.35	A	30	O	0.5	100	150 m	200	8.0	*60*	*350*	*0.4*	*10*	*150 m*		610A
MD6003	CA	.575	A	30	O	0.5	70	150 m	200	8.0			*0.4*	*10*	*150 m*		654
MD6003F	CA	0.35	A	30	O	0.5	70	150 m	200	8.0			*0.4*	*10*	*150 m*		610A
MD6100	CA	0.5	A	45	O	0.05	100	0.1 m	30	4.0			*.25*	*10*	*1.0 m*		654
MD6100F	CA	0.35	A	45	O	0.05	100	0.1 m	30	4.0			*.25*	*10*	*10 m*		610A
MD7000	NA	0.575	A	30	O	0.5	70	150 m	200	8.0			*0.4*	*10*	*150 m*		654
MD7001	PA	0.6	A	30	O	0.6	70	150 m	200	8.0			*0.4*	*10*	*150 m*		654
MD7001F	PA	0.350	A	30	O	0.6	70	150 m	200	8.0			*0.4*	*10*	*150 m*		610A
MD7002	NA	0.575	A	40	O	0.03	40	100 u	200	6.0			*.35*	*10*	*10 m*		654
MD7002A	NM	0.575	A	40	O	0.03	40	100 u	200	6.0	**0.75**	**25**	*.35*	*10*	*10 m*		654
MD7002B	NM	0.575	A	40	O	0.03	40	100 u	200	6.0	**0.85**	**15**	*.35*	*10*	*10 m*		654
MD7003	NA	0.55	A	40	O	0.05	50	10 m	200	6.0			*.35*	*10*	*1.0 m*		654
MD7003A	NM	0.55	A	40	O	0.05	50	10 m	200	6.0	**0.75**	**25**	*.35*	*10*	*1.0 m*		654
MD7003AF	NM	0.35	A	40	O	0.05	50	10 m	200	6.0	**0.75**	**25**	*.35*	*10*	*1.0 m*		610A
MD7003B	NM	0.55	A	40	O	0.05	50	10 m	200	6.0	**0.85**	**15**	*.35*	*10*	*1.0 m*		654
MD7003F	NA	0.35	A	40	O	0.05	50	10 m	200	6.0			*.35*	*10*	*1.0 m*		610A
MD7004	NA	0.55	A	13	O	0.2	30	10 m	675*	4.0			*0.4*	*10*	*10 m*		654
MD7004F	NA	0.35	A	13	O	0.2	30	10 m	675*	4.0			*0.4*	*10*	*10 m*		610A
MD7005	PA	0.55	A	12	O	0.05	30	3.0 m	650	3.0			*0.4*	*10*	*10 m*		654

Some columns show 2 different types of data indicated by either **bold** *or italic typefaces. See key and headings.*

MULTIPLE SMALL-SIGNAL TRANSISTORS (continued)

TABLE 3. Dual Transistors (continued)

TYPE NO.	ID	P_D Watts One Die Only	Ref. Point	V_{CE-} Volts	Subscript	I_C Amp Max	h_{FE} Min	@ I_C	Unit	f_T MHz Min Typ*	C_{ob} pF Max Typ*	h_{FE1}/h_{FE2} ----- *t_{on} ns Max Typ**	ΔV_{BE} mV Max ----- *t_{off} ns Max Typ**	Gp dB Min ----- *V_{CE} (sat) Volts Max*	NF dB Max ----- *@ I_C*	@ f ----- *& I_C/I_B*	Unit	PACKAGE TO- No.	Case No.
MD7005F	PA	0.35	A	12	O	0.05	30	3.0	m	650	3.0			*0.4*	*10*	*10*	*m*		610A
MD7007	PA	0.575	A	40	O	0.2	30	1.0	m	300	8.0			*1.0*	*10*	*50*	*m*		654
MD7007A	PM	0.575	A	50	O	0.2	30	1.0	m	300	8.0	**0.75**	**20**	*1.0*	*10*	*50*	*m*		654
MD7007B	PM	0.575	A	60	O	0.2	30	1.0	m	300	8.0	**0.85**	**10**	*1.0*	*10*	*50*	*m*		654
MD7007BF	PM	0.35	A	40	O	0.2	30	1.0	m	300	8.0	**0.85**	**10**	*1.0*	*10*	*50*	*m*		610A
MD7007F	PA	0.35	A	40	O	0.2	30	1.0	m	300	8.0			*1.0*	*10*	*50*	*m*		610A
MD7021	CG	0.55	A	40	O	0.05	50	10	m	200	6.0	*28**	*72**	*.35*	*10*	*10*	*m*		654
MD7021F	CG	0.35	A	40	O	0.05	50	10	m	200	6.0	*28**	*72**	*.35*	*10*	*10*	*m*		610A
MD8001	NM	0.575	A	40	O	0.03	100	1.0	m	260*	2.6*		**15**						654
MD8002	NM	0.575	A	40	O	0.03	100	1.0	m	260*	2.6*		**15**						654
MD8003	NM	0.575	A	40	O	0.03	100	1.0	m	260*	2.6*		**15**						654
2N2060	NM	0.5	A	60	O	0.5	30	100	u	60	15	**0.9**	**5.0**		**8.0**	**1000**	**H**	78	654
2N2060A	NM	0.5	A	60	O	0.5	30	100	u	60	15	**0.9**	**3.0**	*0.6*	*10*	*50*	*m*	78	654
2N2223	NM	0.5	A	60	O	0.5	25	100	u	50	15	**0.8**	**15**	*1.2*	*10*	*50*	*m*	78	654
2N2223A	NM	0.5	A	60	O	0.5	25	100	u	50	15	**0.9**	**5.0**	*1.2*	*10*	*50*	*m*	78	654
2N2453	NM	0.5	A	30	O	0.05	80	10	u	60	8.0	**0.9**	**3.0**		**7.0**	**1000**	**H**	78	654
2N2453A	NM	0.5	A	50	O	0.05	80	10	u	60	8.0	**0.9**	**3.0**		**4.0**	**1000**	**H**	78	654
2N2480	NM	0.3	A	35	O	0.5	30	1.0	m	50	20	**0.8**	**10**		**8.0**	**1000**	**H**	78	654
2N2480A	NM	0.3	A	40	O	0.5	50	1.0	m	50	18	**0.8**	**5.0**	*1.3*	*10*	*50*	*m*	78	654
2N2639	NM	0.3	A	45	O	0.03	50	10	u	80	8.0	**0.9**	**5.0**		**4.0**	**AUD**		78	654
2N2640	NM	0.3	A	45	O	0.03	50	10	u	80	8.0	**0.8**	**10**		**4.0**	**AUD**		78	654
2N2641	NE	0.3	A	45	O	0.03	50	10	u	80	8.0				**4.0**	**AUD**		78	654
2N2642	NM	0.3	A	45	O	0.03	100	10	u	80	8.0	**0.9**	**5.0**		**4.0**	**AUD**		78	654
2N2643	NM	0.3	A	45	O	0.03	100	10	u	80	8.0	**0.8**	**10**		**4.0**	**AUD**		78	654
2N2644	NE	0.3	A	45	O	0.03	100	10	u	80	8.0				**4.0**	**AUD**		78	654
2N2652	NM	0.3	A	60	O	0.5	50	1.0	m	60	15	**0.85**	**3.0**	*1.2*	*10*	*50*	*m*	78	654
2N2652A	NM	0.3	A	60	O	0.5	50	1.0	m	60	15	**0.9**	**3.0**		**8.0**	**1000**	**H**	78	654
2N2720	NM	0.3	A	60	O	0.04	30	0.1	m	80	6.0	**0.9**	**5.0**	*1.0*	*10*	*10*	*m*	78	654
2N2721	NM	0.3	A	60	O	0.04	30	0.1	m	80	6.0	**0.8**	**10**	*1.0*	*10*	*10*	*m*	78	654
2N2722	NM	0.3	A	45	O	0.04	50	1.0	u	100	6.0	**0.9**	**5.0**	*1.0*	*20*	*10*	*m*	78	654
2N2903	NM	0.6	C	30	O	0.05	125	1.0	m	60	8.0	**0.8**	**10**		**7.0**	**1000**	**H**	78	654
2N2903A	NM	0.6	C	30	O	0.05	125	1.0	m	60	8.0	**0.9**	**5.0**		**7.0**	**1000**	**H**	78	654
2N2913	NE	0.3	A	45	O	0.03	60	10	u	60	6.0				**4.0**	**AUD**			654
2N2914	NE	0.3	A	45	O	0.03	150	10	u	60	6.0				**3.0**	**AUD**			654
2N2915	NM	0.3	A	45	O	0.03	60	10	u	60	6.0	**0.9**	**5.0**		**4.0**	**AUD**			654
2N2916	NM	0.3	A	45	O	0.03	150	10	u	60	6.0	**0.9**	**5.0**		**3.0**	**AUD**			654
2N2917	NM	0.3	A	45	O	0.03	60	10	u	60	6.0	**0.8**	**10**		**4.0**	**AUD**			654
2N2918	NM	0.3	A	45	O	0.03	150	10	u	60	6.0	**0.8**	**10**		**3.0**	**AUD**			654
2N2919	NM	0.3	A	60	O	0.03	60	10	u	60	6.0	**0.9**	**5.0**		**4.0**	**AUD**			654
2N2920	NM	0.3	A	60	O	0.03	150	10	u	60	6.0	**0.9**	**5.0**		**3.0**	**AUD**			654
2N3043	NM	0.25	A	45	O	0.03	100	10	u	30	8.0	**0.9**	**5.0**		**5.0**	**AUD**			610A
2N3044	NM	0.25	A	45	O	0.03	100	10	u	30	8.0	**0.8**	**10**		**5.0**	**AUD**			610A
2N3045	NE	0.25	A	45	O	0.03	100	10	u	30	8.0				**5.0**	**AUD**			610A
2N3046	NM	0.25	A	45	O	0.03	50	10	u	30	8.0	**0.9**	**5.0**		**5.0**	**AUD**			610A
2N3047	NM	0.25	A	45	O	0.03	50	10	u	30	8.0	**0.8**	**10**		**5.0**	**AUD**			610A
2N3048	NE	0.25	A	45	O	0.03	50	10	u	30	8.0				**5.0**	**AUD**			610A
2N3726	PE	0.4	A	45	O	0.3	135	1.0	m	200	8.0	**0.9**	**5.0**		**4.0**	**1000**	**H**		654

Some columns show 2 different types of data indicated by either **bold** *or* *italic* *typefaces. See key and headings.*

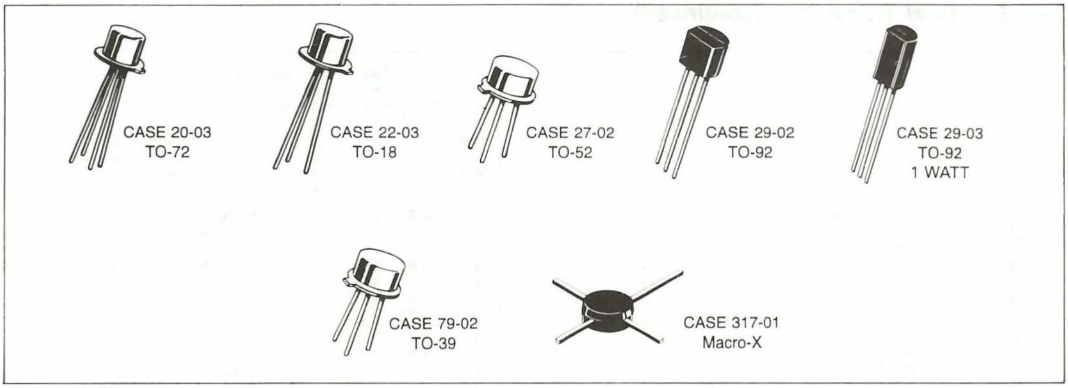
TABLE 3. Dual Transistors (continued)

TYPE NO.	ID	P_D Watts One Die Only	Ref. Point	V_{CE-} Volts	Subscript	I_C Amp Max	h_{FE} Min	@ I_C	Unit	f_T MHz Min	C_{ob} pF Max	h_{FE1}/h_{FE2} ----- t_{on} ns Max	ΔV_{BE} mV Max ----- t_{off} ns Max	Gp dB Min ----- V_{CE} (sat) Volts Max	NF dB Max ----- @ I_C/I_B	@ f ----- & I_C	Unit	PACKAGE TO- No.	PACKAGE Case No.
2N3727	PE	0.4	A	45	O	0.3	135	1.0	m	200	8.0	**0.9**	**2.5**		**4.0**	**1000**	**H**		654
2N3806	PE	0.5	A	60	O	0.05	150	0.1	m	100	4.0				**7.0**	**100**	**H**		654
2N3807	PE	0.5	A	60	O	0.05	300	0.1	m	100	4.0				**4.0**	**100**	**H**		654
2N3808	PM	0.5	A	60	O	0.05	150	0.1	m	100	4.0	**0.8**	**5.0**		**7.0**	**100**	**H**		654
2N3809	PM	0.5	A	60	O	0.05	300	0.1	m	100	4.0	**0.8**	**5.0**		**4.0**	**100**	**H**		654
2N3810	PM	0.5	A	60	O	0.05	150	0.1	m	100	4.0	**0.9**	**3.0**		**7.0**	**100**	**H**		654
2N3810A	PM	0.5	A	60	O	0.05	150	0.1	m	100	4.0	**0.95**	**1.5**		**3.0**	**100**	**H**		654
2N3811	PM	0.5	A	60	O	0.05	300	0.1	m	100	4.0	**0.9**	**3.0**		**4.0**	**100**	**H**		654
2N3811A	PM	0.5	A	60	O	0.05	300	0.1	m	100	4.0	**0.95**	**1.5**		**1.5**	**100**	**H**		654
2N3812	PM	0.5	A	60	O	0.05	150	0.1	m	100	4.0				**3.5**	**AUD**			610A
2N3813	PA	0.5	A	60	O	0.05	300	0.1	m	100	4.0				**2.5**	**AUD**			610A
2N3814	PM	0.5	A	60	O	0.05	150	0.1	m	100	4.0	**0.8**	**5.0**		**7.0**	**100**	**H**		610A
2N3815	PM	0.5	A	60	O	0.05	300	0.1	m	100	4.0	**0.8**	**5.0**		**4.0**	**100**	**H**		610A
2N3816	PM	0.5	A	60	O	0.05	150	0.1	m	100	4.0	**0.9**	**3.0**		**7.0**	**100**	**H**		610A
2N3816A	PM	0.5	A	60	O	0.05	150	0.1	m	100	4.0	**0.95**	**1.5**		**7.0**	**100**	**H**		610A
2N3817	PM	0.5	A	60	O	0.05	300	0.1	m	100	4.0	**0.9**	**3.0**		**4.0**	**100**	**H**		610A
2N3817A	PM	0.5	A	60	O	0.05	300	0.1	m	100	4.0	**0.95**	**1.5**		**4.0**	**100**	**H**		610A
2N3838	CE	0.25	A	40	O	0.6	100	150	m	200	8.0	*50*	*340*		**8.0**	**1000**	**H**		610A
2N4015	PM	0.4	A	60	O	0.3	135	1.0	m	200	8.0	**0.9**	**5.0**		**4.0**	**1000**	**H**		654
2N4016	PM	0.4	A	60	O	0.3	135	1.0	m	200	8.0	**0.9**	**2.5**		**4.0**	**1000**	**H**		654
2N4854	CE	0.3	A	40	O	0.6	100	150	m	200	8.0	*60*	*350*		**8.0**	**1000**	**H**		654
2N4855	CE	0.3	A	40	O	0.6	40	150	m	200	8.0	*60*	*350*		**8.0**	**1000**	**H**		654
2N4937	PM	0.6	A	40	O	0.05	50	1.0	m	300	5.0	**0.9**	**3.0**		**4.0**	**AUD**			654
2N4938	PM	0.6	A	40	O	0.05	50	1.0	m	300	5.0	**0.8**	**5.0**		**4.0**	**AUD**			654
2N4939	PE	0.6	A	40	O	0.05	50	1.0	m	300	5.0				**4.0**	**AUD**			654
2N4940	PM	0.6	A	40	O	0.05	50	1.0	m	300	5.0	**0.8**	**5.0**		**4.0**	**AUD**			610A
2N4941	PM	0.6	A	40	O	0.05	50	1.0	m	300	5.0	**0.9**	**3.0**		**4.0**	**AUD**			610A
2N4942	PE	0.6	A	40	O	0.05	50	1.0	m	300	5.0				**4.0**	**AUD**			610A
2N5793	NG	0.5	A	40	O	0.6	40	150	m	200	8.0	*45*	*310*	*0.3*	*10*	*150*	*m*		654
2N5794	NG	0.5	A	40	O	0.6	100	150	m	200	8.0	*45*	*310*	*0.3*	*10*	*150*	*m*		654
2N5795	NG	0.5	A	60	O	0.6	40	150	m	200	8.0	*47*	*140*	*0.4*	*10*	*150*	*m*		654
2N5796	NG	0.5	A	60	O	0.6	100	150	m	200	8.0	*47*	*140*	*0.4*	*10*	*150*	*m*		654
2N6502	NS	0.6	A	40	O	1.0	50	100	m	250	10	*35*	*60*	*0.3*	*10*	*100*	*m*		654
2N6503	NS	0.6	A	40	O	1.0	50	100	m	250	10	*35*	*60*	*0.3*	*10*	*100*	*m*		610A

Some columns show 2 different types of data indicated by either **bold** *or italic typefaces. See key and headings.*

1

Field-Effect Transistors



Motorola offers a line of field-effect transistors that encompasses the latest technology and covers the full range of FET applications. Included here is a wide variety of junction FETs, MOSFETs (with P- or N-channel polarity with both single and dual gates) and TMOS FETs. These FETs include devices developed for operation across the frequency range from dc to UHF in switching and amplifying applications. Package options from low cost plastic to metal TO-72 packages are available. The selector guides on the following pages are designed to emphasize those FET families and device types that, by virtue of widespread industry use, ease of manufacture and, consequently, low relative cost, merit first consideration for new equipment design.

JFETs

JFETs

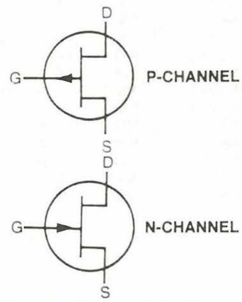


TABLE 1. Switches and Choppers

JFETs operate in the depletion mode. They are available in both P- and N-channel and are offered in both metal and plastic packages. Applications include general-purpose amplifiers, switches and choppers, and RF amplifiers and mixers. These devices are economical and very rugged. The drain and source are interchangeable on many typical FETs.

P-Channel JFETs

Package TO –	Device	$r_{ds(on)}$ (Ω) MAX	@ I_D (μA)	$V_{GS(off)}$ (V) MIN	MAX	I_{DSS} (mA) MIN	MAX	$V_{(BR)GSS}$ $V_{(BR)GDO}$ (V) MIN	C_{iss} (pF) MAX	C_{rss} (pF) MAX	t_{on} (ns) MAX	t_{off} (ns) MAX
92	MPF970	100	1.0	5.0	12	15	100	30	12	5.0	8.0	25
92	MPF971	250	1.0	1.0	7.0	2.0	80	30	12	5.0	10	120
72	2N3993	150	—	4.0	9.5	10	—	25	16	4.5	—	—
72	2N3994	300	—	1.0	5.5	2.0	—	25	16	4.5	—	—
72	2N3994A	300	—	1.0	5.5	2.0	—	25	12	3.0	—	—

N-Channel JFETs

Package TO –	Device	$r_{ds(on)}$ (Ω) MAX	@ I_D (μA)	$V_{GS(off)}$ (V) MIN	MAX	I_{DSS} (mA) MIN	MAX	$V_{(BR)GSS}$ $V_{(BR)GDO}$ (V) MIN	C_{iss} (pF) MAX	C_{rss} (pF) MAX	t_{on} (ns) MAX	t_{off} (ns) MAX
18	MFE2012	10	—	3.0	10	100	—	25	50	20	16	37
18	MFE2011	15	1.0	1.0	10	40	—	25	50	20	10	20
18	2N4859A	25	—	2.0	6.0	50	—	30	10	4.0	8.0	20
92	MPF4859A	25	—	2.0	6.0	50	—	30	10	4.0	8.0	20
18	2N4856A	25	—	4.0	10	50	—	40	10	4.0	8.0	20
92	MPF4856A	25	—	4.0	10	50	—	40	10	4.0	8.0	20
18	2N4856	26	—	4.0	10	50	—	40	10	8.0	9.0	25
92	MPF4856	25	—	4.0	10	50	—	40	10	8.0	9.0	25

FIELD-EFFECT TRANSISTORS (continued)

TABLE 1. Switches and Choppers (continued)

N-Channel JFETs (continued)

Package TO –	Device	$r_{ds(on)}$ (Ω) MAX	@ I_D (μA)	$V_{GS(off)}$ (V) MIN	$V_{GS(off)}$ (V) MAX	I_{DSS} (mA) MIN	I_{DSS} (mA) MAX	$V_{(BR)GSS}$ $V_{(BR)GDO}$ (V) MIN	C_{iss} (pF) MAX	C_{rss} (pF) MAX	t_{on} (ns) MAX	t_{off} (ns) MAX
18	2N4859	25	—	4.0	10	50	—	30	18	8.0	9.0	25
92	MPF4859	25	—	4.0	10	50	—	30	18	8.0	9.0	25
18	MFE2010	25	1.0	0.5	10	15	—	25	50	20	10	35
18	2N4391	30	1.0	4.0	10	50	150	40	14	3.5	15	20
92	MPF4391	30	1.0	4.0	10	60	130	20	10	3.5	15	20
92	2N638	30	1.0	—	(12)	50	—	30	10	4.0	9.0	15
18	2N4091	30	1.0	5.0	10	30	—	40	16	5.0	25	40
92	MPF4091	30	1.0	5.0	10	30	—	40	16	5.0	25	40
92	J111	30	1.0	3.0	10	20	—	35	10[t]	5.0[t]	13	35
18	MFE2006	30	1.0	−5.0	−10	30	—	−30	16	5.0	20	40
18	2N3970	30	1.0	4.0	10	50	150	40	25	6.0	20	30
92	MPF3970	30	1.0	4.0	10	50	150	40	25	6.0	20	30
18	2N4057A	40	—	2.0	6.0	20	100	40	10	3.5	10	40
92	MPF4857A	40	—	2.0	6.0	20	100	40	10	3.5	10	40
18	2N860A	40	—	2.0	6.0	20	100	30	10	3.5	10	40
92	MPF4860A	40	—	2.0	6.0	20	100	30	10	3.5	10	40
18	2N4857	40	—	2.0	6.0	20	100	40	18	8.0	10	50
92	MPF4857	40	—	2.0	6.0	20	100	40	18	8.0	10	50
18	2N4860	40	—	2.0	6.0	20	100	30	18	8.0	10	50
92	MPF4860	40	—	2.0	6.0	20	100	30	18	8.0	10	50
92	2N5653	50	1.0	—	(12)[t]	40	—	30	10	3.5	9.0	15
18	2N4092	50	1.0	2.0	7.0	15	—	40	16	5.0	35	60
92	MPF4092	50	1.0	2.0	7.0	15	—	40	16	5.0	35	60
92	J112	50	1.0	1.0	5.0	5.0	—	35	10[t]	5.0[t]	13[t]	35[t]
18	MFE2005	50	1.0	−2.0	−8.0	15	—	−30	16	5.0	35	60
18	2N4392	60	1.0	2.0	5.0	25	75	40	14	3.5	15	35
92	MPF4392	60	1.0	2.0	5.0	25	75	20	10	3.5	15	35
18	2N4858A	60	1.0	0.8	4.0	8.0	80	40	10	3.5	16	80
92	MPF4858A	60	1.0	0.8	4.0	8.0	80	40	10	3.5	16	80
18	2N4861A	60	—	0.8	4.0	8.0	80	30	10	3.5	16	80
92	MPF4861A	60	—	0.8	4.0	8.0	80	30	10	3.5	16	80
92	2N5639	60	1.0	—	(8.0)[t]	25	—	30	10	4.0	14	30
18	2N3971	60	1.0	2.0	5.0	25	75	40	25	6.0	30	60
92	MPF3971	60	1.0	2.0	5.0	25	75	40	25	6.0	30	60
18	2N4858	60	—	0.8	4.0	8.0	80	40	18	8.0	20	100
92	MPF4858	60	—	0.8	4.0	8.0	80	40	18	8.0	20	100
18	2N4861	60	—	0.8	4.0	8.0	80	30	18	8.0	20	100
92	MPF4861	60	—	0.8	4.0	8.0	80	30	18	8.0	20	100
18	2N4093	80	1.0	1.0	5.0	80	—	40	16	5.0	60	80
92	MPF4093	80	1.0	1.0	5.0	80	—	40	16	5.0	60	80
18	MFE2004	80	1.0	−1.0	−6.0	8.0	—	−30	16	5.0	60	80
72	MFE3002	100	10 V	—	3.0	—	10	15	5.0	1.5	—	—
18	2N4393	100	1.0	0.5	3.0	5.0	30	40	14	3.5	15	50
92	MPF4393	100	1.0	0.5	3.0	5.0	30	20	10	3.5	15	55
92	2N5654	100	1.0	—	(8.0)	15	—	25	10	3.5	14	30
92	2N5640	100	1.0	—	(6.0)	5.0	—	30	10	4.0	18	45

FIELD-EFFECT TRANSISTORS (continued)

TABLE 1. Switches and Choppers (continued)

N-Channel JFETs (continued)

		$r_{ds(on)}$		$V_{GS(off)}$ (V)		I_{DSS} (mA)		$V_{(BR)GSS}$ $V_{(BR)GDO}$	C_{iss}	C_{rss}	t_{on}	t_{off}
Package TO –	Device	(Ω) MAX	@ I_D (μA)	MIN	MAX	MIN	MAX	(V) MIN	(pF) MAX	(pF) MAX	(ns) MAX	(ns) MAX
18	2N3972	100	1.0	0.5	3.0	5.0	30	40	25	6.0	80	100
92	MPF3972	100	1.0	0.5	3.0	5.0	30	40	25	6.0	80	100
92	J113	100	1.0	0.5	3.0	2.0	—	35	10^t	5.0^t	13^t	35^t
92	BF246	—	—	0.5	14	10	300	25	—	—	—	—
92	BF246A	35^t	1.0	1.5	4.0	30	80	25	—	—	—	—
92	BF246B	50^t	1.0	3.0	7.0	60	140	25	—	—	—	—
92	BF246C	65^t	1.0	5.5	12.0	110	250	25	—	—	—	—
92	J107	8	—	0.5	4.5	100	—	25	—	—	—	—
92	J108	8	—	3.0	10.0	80	—	25	—	—	—	—
92	J109	12	—	2.0	6.0	40	—	25	—	—	—	—
92	J110	18	—	0.5	4.0	10	—	25	—	—	—	—

t = typical

TABLE 2. Low-Frequency/Low-Noise

P-Channel JFETs

		$R_e\|Y_{fs}\|$	$R_e\|Y_{os}\|$	C_{iss}	C_{rss}	$V_{(BR)GSS}$ $V_{(BR)GDO}$	$V_{GS(off)}$ (V)		I_{DSS} (mA)	
Package TO –	Device	(mmho) MIN	(μmho) MAX	(pF) (MAX)	(pF) MAX	(V) MIN	MIN	MAX	MIN	MAX
92	MPF161	0.8	75	7.0	2.0	40	0.2	8.0	–0.5	–14
72	2N5265	0.9	75	7.0	2.0	60	0.3	1.5	0.5	1.0
72	MFE4009	1.0	20	20	—	20	—	5.0	1.0	3.0
72	MFE4012	1.0	100	20	—	20	—	8.0	5.0	15
72	2N5267/8	1.0	20	20	—	20	—	6.0	1.0	6.0
72	2N3909	1.0	100	32	16	20	0.3	7.9	0.3	15
18	MFE4007	1.0	20	25	7.0	25	0.3	1.5	0.3	1.2
28	2N2608	1.0	17	—	—	30	1.0	4.0	0.9	4.5
92	MPF2608	1.0	—	17	—	30	1.0	4.0	0.9	4.5
92	2N5460	1.0	50	7.0	2.0	40	0.75	6.0	1.0	5.0
72	2N5266	1.0	75	7.0	2.0	60	0.4	2.0	0.8	1.6
92	2N5463	1.0	75	7.0	2.0	60	0.5	4.0	1.0	5.0
72	2N3330	1.5	40	20	—	20	—	6.0	2.0	6.0
92	MPF3330	1.5	40	20	—	20	—	6.0	2.0	6.0
18	MFE4009	1.5	20	25	7.0	25	0.5	2.5	1.0	3.5
92	2N5461	1.5	50	7.0	2.0	40	1.0	7.5	2.0	9.0
72	2N5267	1.5	75	7.0	2.0	60	1.0	4.0	1.5	3.0
92	2N5464	1.5	75	7.0	2.0	60	0.8	4.5	2.0	9.0
92	2N4360	2.0	100	20	5.0	20	0.4	9.0	3.0	30
92	2N4342	2.0	75	20	5.0	25	—	5.5	4.0	12
92	2N5462	2.0	50	7.0	2.0	40	1.8	9.0	4.0	16
72	2N5268	2.0	75	7.0	2.0	60	1.0	4.0	2.5	5.0

FIELD-EFFECT TRANSISTORS (continued)

TABLE 2. Low-Frequency/Low-Noise (continued)

P-Channel JFETs

Package TO –	Device	$R_e \vert Y_{fs} \vert$ (mmho) MIN	$R_e \vert Y_{os} \vert$ (µmho) MAX	C_{iss} (pF) (MAX)	C_{rss} (pF) MAX	$V_{(BR)GSS}$ $V_{(BR)GDO}$ (V) MIN	$V_{GS(off)}$ (V) MIN	$V_{GS(off)}$ (V) MAX	I_{DSS} (mA) MIN	I_{DSS} (mA) MAX
92	2N5465	2.0	75	7.0	2.0	60	1.5	6.0	4.0	16
72	2N3909A	2.2	100	9.0	3.0	20	0.3	7.9	1.0	15
72	2N5269	2.2	75	7.0	2.0	60	2.0	6.0	4.0	8.0
18	2N2609	2.5	—	30	—	30	1.0	4.0	2.0	10
92	MPF2609	2.5	—	30	—	30	1.0	4.0	2.0	10
72	2N5270	2.5	75	7.0	2.0	60	2.0	6.0	7.0	14

N-Channel JFETs

Package TO –	Device	$R_e \vert Y_{fs} \vert$ (mmho) MIN	$R_e \vert Y_{fs} \vert$ @ f (MHz)	$R_e \vert Y_{os} \vert$ (µmho) MAX	$R_e \vert Y_{os} \vert$ @ f (MHz)	C_{iss} (pF) (MAX)	C_{rss} (pF) MAX	$V_{(BR)GSS}$ $V_{(BR)GDO}$ (V) MIN	$V_{GS(off)}$ (V) MIN	$V_{GS(off)}$ (V) MAX	I_{DSS} (mA) MIN	I_{DSS} (mA) MAX
18	2N3370	0.3	30	15	30	20	3.0	40	—	3.2	0.1	0.6
92	MPF111	0.5	10	200	10	—	—	20	0.5	10	0.5	20
92	J201	0.5	20	1.0^{t}	20	5.0^{t}	2.0^{t}	40	0.3	1.5	0.2	1.0
18	2N3369	0.6	30	30	30	20	3.0	40	—	6.5	0.5	2.5
92	MPF109	0.8	15	75	15	7.0	3.0	25	0.2	8.0	0.5	24
18	2N4339	0.8	15	15	15	7.0	3.0	50	0.6	1.8	0.5	1.5
92	MPF4339	0.8	15	15	15	7.0	3.0	50	0.6	1.8	0.5	1.5
18	2N3460	0.8	20	5.0	30	18	6.0	50	—	1.8	0.2	1.0
18	2N3438	0.8	20	5.0	30	18	6.0	50	—	2.3	0.2	1.0
72	2N4220	1.0	15	10	15	6.0	2.0	30	—	4.0	0.5	3.0
92	MPF4220	1.0	15	10	15	6.0	2.0	30	—	4.0	0.5	3.0
72	2N4220A	1.0	15	10	15	6.0	2.0	30	—	4.0	0.5	3.0
92	MPF4220A	1.0	15	10	15	6.0	2.0	30	—	4.0	0.5	3.0
72	2N5358	1.0	15	10	15	6.0	2.0	40	0.5	3.0	0.5	1.0
92	J202	1.0	20	3.5^{t}	20	5.0^{t}	2.0^{t}	40	0.8	4.0	0.9	4.5
18	2N3368	1.0	30	80	30	20	3.0	40	—	11.5	2.0	12
72	2N5359	1.2	15	10	15	6.0	2.0	40	0.8	4.0	0.6	1.6
18	2N4340	1.3	15	30	15	7.0	3.0	50	1.0	3.0	1.2	3.6
72	2N5360	1.4	15	20	15	6.0	2.0	40	0.8	4.0	0.5	2.5
94	2N5458	1.5	15	50	15	7.0	3.0	25	1.0	7.0	2.0	9.0
72	2N5361	1.5	15	20	15	6.0	2.0	40	1.0	6.0	2.5	5.0
92	J203	1.5	20	10^{t}	20	5.0^{t}	2.0^{t}	40	2.0	10	4.0	20
18	2N3459	1.5	20	20	30	18	6.0	50	—	3.4	0.8	4.0
72	2N3821	1.5	15	10	15	6.0	3.0	50	—	4.0	0.5	2.5
92	MPF3821	1.5	15	10	15	6.0	3.0	50	—	4.0	0.5	2.5
18	2N3437	1.5	20	20	30	18	6.0	50	—	4.8	0.8	4.0
92	2N5457	2.0	15	50	15	7.0	3.0	25	0.5	6.0	1.0	5.0
92	2N5459	2.0	15	50	15	7.0	3.0	25	2.0	8.0	4.0	16
72	2N4221	2.0	15	20	15	6.0	2.0	30	—	6.0	2.0	6.0

t = typical

FIELD-EFFECT TRANSISTORS (continued)

TABLE 2. Low-Frequency/Low-Noise (continued)

N-Channel JFETs

Package TO –	Device	$R_e\|Y_{fs}\|$ (mmho) MIN	@ f (MHz)	$R_e\|Y_{os}\|$ (μmho) MAX	@ f (MHz)	C_{iss} (pF) (MAX)	C_{rss} (pF) MAX	$V_{(BR)GSS}$ $V_{(BR)GDO}$ (V) MIN	$V_{GS(off)}$ (V) MIN	$V_{GS(off)}$ (V) MAX	I_{DSS} (mA) MIN	I_{DSS} (mA) MAX
92	MPF4221	2.0	15	20	15	6.0	2.0	30	—	6.0	2.0	6.0
72	2N4221A	2.0	15	20	15	6.0	2.0	30	—	6.0	2.0	6.0
92	MPF4221A	2.0	15	20	15	6.0	2.0	30	—	6.0	2.0	6.0
72	2N5362	2.0	15	40	15	6.0	2.0	40	2.0	7.0	4.0	8.0
72	2N3822	2.0	15	20	15	6.0	3.0	50	—	6.0	2.0	10
92	MPF3822	2.0	15	20	15	6.0	3.0	50	—	6.0	2.0	10
18	2N4341	2.0	15	60	15	7.0	3.0	50	2.0	6.0	3.0	9.0
72	2N4222	2.5	15	40	15	6.0	2.0	30	—	8.0	5.0	15
92	MPF4222	2.5	15	40	15	6.0	2.0	30	—	8.0	5.0	15
72	2N4222A	2.5	15	40	15	6.0	2.0	30	—	8.0	5.0	15
92	MPF4222A	2.5	15	40	15	6.0	2.0	30	—	8.0	5.0	15
72	2N5363	2.5	15	40	15	6.0	2.0	40	2.5	8.0	7.0	14
18	2N3458	2.5	20	35	30	18	6.0	50	—	7.8	3.0	15
18	2N3436	2.5	20	35	30	18	6.0	50	—	9.8	3.0	15
72	2N5364	2.7	15	60	15	6.0	2.0	40	2.5	8.0	9.0	18
92	2N5670	3.0	15	75	15	7.0	3.0	25	2.0	8.0	8.0	20
18	2N4398	12[t]	0.001	—	—	14	3.5	40	0.5	3.0	5.0	30
72	2N5556	6.5	0.001	20	15	6.0	3.0	30	0.2	4.0	0.5	2.5
72	2N4117	20	0.001	3.0	10	3.0	1.5	40	0.6	1.8	30	90
92	MPF4117	20	0.001	3.0	10	3.0	1.5	40	0.6	1.8	30	90
72	2N4117A	70	0.001	3.0	10	3.0	1.5	40	0.6	1.8	30	90
92	MPF4117A	70	0.001	3.0	10	3.0	1.5	40	0.6	1.8	30	90
72	2N4118	80	0.001	5.0	10	3.0	1.5	40	1.0	3.0	80	240
92	MPF4118	80	0.001	5.0	10	3.0	1.5	40	1.0	3.0	80	240
72	2N4118A	80	0.001	5.0	10	3.0	1.5	40	1.0	3.0	80	240
92	MPF4118A	80	0.001	5.0	10	3.0	1.5	40	1.0	3.0	80	240
72	2N4119	100	0.001	10	10	3.0	1.5	40	2.0	6.0	200	600
92	MPF4119	100	0.001	10	10	3.0	1.5	40	2.0	6.0	200	600
72	2N4119A	100	0.001	10	10	3.0	1.5	40	2.0	6.0	200	600
92	MPF4119A	100	0.001	10	10	3.0	1.5	40	2.0	6.0	200	600

t = typical

MOSFETs

MOSFETs are available in either depletion/enhancement or enhancement mode (in general, depletion/enhancement devices are operated in the depletion mode and are referred to as depletion devices). They are available in both N- and P-channel, and both single gate and dual gate construction. Some MOSFETs are also offered with input diode protection which reduces the chance of damage from static charge in handling.

MOSFETs Single Gate

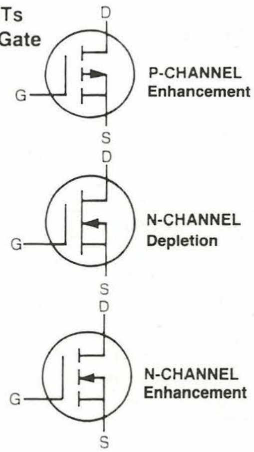


TABLE 2. Low-Frequency/Low-Noise (continued)

P-Channel MOSFETs

Package TO –	Device	Re|Yfs| (mmho) MIN	Re|Yfs| (μmho) MAX	C_{iss} (pF) (MAX)	C_{rss} (pF) MAX	$V_{(BR)DSS}$ (V) MIN	$V_{GS(TH)}$ (V) MIN	$V_{GS(TH)}$ (V) MAX	I_{DSS} (mA) MIN	I_{DSS} (mA) MAX
72	3N155	1.0	60	5.0	1.3	−35	−1.5	−3.2	—	−1.0
72	3N156	1.0	60	5.0	1.3	−35	−3.0	−5.0	—	−1.0
72	3N157	1.0	60	5.0	1.3	−35	−1.5	−3.2	—	−1.0
72	3N155A	1.0	60	5.0	1.3	−35	−1.5	−3.2	—	−0.25
72	3N156A	1.0	60	5.0	1.3	−35	−3.0	−5.0	—	−0.25
72	3N157A	1.0	60	5.0	1.3	−50	−1.5	−3.2	—	−0.25
72	3N158	1.0	60	5.0	1.3	−35	−3.0	−5.0	—	−1.0
72	3N158A	1.0	60	5.0	1.3	−25	−2.0	−6.0	—	−20
18	MFE823	1.0	—	6.0	1.5	−50	−3.0	−5.0	—	−0.25
72	MFE3003	—	—	5.0	1.0	−15	—	−4.0	—	10

N-Channel MOSFETs

Package TO –	Device	Re|Yfs| (mmho) MIN	Re|Yfs| (μmho) MAX	C_{iss} (pF) (MAX)	C_{rss} (pF) MAX	$V_{(BR)DSS}$ (V) MIN	$V_{GS(TH)}$ (V) MIN	$V_{GS(TH)}$ (V) MAX	I_{DSS} (mA) MIN	I_{DSS} (mA) MAX
18	2N3796	0.4	1.8	7.0	0.8	25	—	−7.0	2.0	6.0
18	MFE825	0.5	—	4.0	0.7	20	—	—	1.0	25
72	2N4351	1.0	—	5.0	1.3	25	1.0	5.0	—	10
72	3N169	1.0	—	5.0	1.3	25	0.5	1.5	—	10
72	3N170	1.0	—	5.0	1.3	25	1.0	2.0	—	10
72	3N171	1.0	—	5.0	1.3	25	1.5	3.0	—	10
72	MFE3002	—	—	5.0	1.0	15	—	3.0	—	10
18	2N3797	1.5	—	8.0	0.8	25	—	−7.0	2.0	6.0

FIELD-EFFECT TRANSISTORS (continued)

TABLE 3. High-Frequency Amplifiers

N-Channel JFETs

Package TO –	Device	$R_e \lvert Y_{fs} \rvert$ (mmho) MIN	@ f (MHz)	$R_e \lvert Y_{os} \rvert$ (μmho) MAX	@ f (MHz)	C_{iss} (pF) (MAX)	C_{rss} (pF) MAX	NF (dB) MAX	@ RG = 1K f (MHz)	$V_{(BR)GSS}$ $V_{(BR)GDO}$ (V) MIN	$V_{GS(off)}$ (V) MIN	$V_{GS(off)}$ (V) MAX	I_{DSS} (mA) MIN	I_{DSS} (mA) MAX
92	2N5669	1.6	100	100	100	7.0	3.0	2.5	100	25	1.0	6.0	4.0	10
92	MPF108	1.6	100	200	100	6.5	2.5	3.0	100	25	—	8.0	1.5	24
92	MPF102	1.6	100	200	100	7.0	3.0	—	—	25	—	8.0	2.0	20
92	2N3819	1.6	100	—	—	8.0	4.0	—	—	25	—	8.0	2.0	20
92	2N5668	1.0	100	50	100	7.0	3.0	2.5	100	25	0.2	4.0	1.0	5.0
72	2N4224	1.7	200	200	200	6.0	2.0	—	—	30	0.1	8.0	20	20
92	MPF4224	1.7	200	200	200	6.0	2.0	—	—	30	0.1	8.0	2.0	20
92	2N5484	2.5	100	75	100	5.0	1.0	3.0	100	25	0.3	3.0	1.0	5.0
72	MFE2000	2.5	0.001	50	0.001	5.0	1.0	4.0	400	−25	−0.5	−0.4	4.0	10
92	2N5670	2.5	100	150	100	7.0	3.0	2.5	100	25	2.0	8.0	8.0	20
92	2N5246	2.5	400	100	400	4.5	1.0	—	—	30	0.5	4.0	1.5	7.0
72	2N4223	2.7	200	200	200	6.0	2.0	5.0	200	30	0.1	8.0	3.0	18
92	MPF4223	2.7	200	200	200	6.0	2.0	5.0	200	30	0.1	8.0	3.0	18
92	2N5485	3.0	400	100	400	5.0	1.0	4.0	400	25	1.0	4.0	4.0	10
92	J305	3.0^{t}	400	80^{t}	100	3.0^{t}	0.8^{t}	4.0^{t}	400	30	0.5	3.0	1.0	8.0
72	2N3823	3.2	200	200	200	6.0	2.0	2.5	100	30	—	8.0	4.0	20
92	MPF3823	3.2	200	200	200	6.0	2.0	2.5	100	30	—	8.0	4.0	20
92	2N5486	3.5	400	100	400	5.0	1.0	4.0	400	25	2.0	6.0	8.0	20
72	MFE2001	4.0	0.001	75	0.001	5.0	1.0	4.0	400	−25	−2.0	−6.0	8.0	20
72	2N4416	4.0	400	100	400	4.0	0.8	4.0	400	30	2.0	6.0	5.0	15
92	MPF4416	4.0	400	100	400	4.0	0.8	4.0	400	30	2.0	6.0	5.0	15
72	2N4416A	4.0	400	100	400	4.0	0.8	4.0	400	30	2.0	6.0	5.0	15
92	MPF4416A	4.0	400	100	400	4.0	0.8	4.0	400	30	2.0	6.0	5.0	15
92	2N5245	4.0	400	100	400	4.5	1.0	4.0	400	30	1.0	6.0	5.0	15
92	2N5247	4.0	400	150	400	4.5	1.0	4.0	400	30	1.5	8.0	8.0	24
92	J304	4.2^{t}	400	80^{t}	100	3.0^{t}	0.8^{t}	4.0^{t}	400	30	2.0	6.0	5.0	15
52	U308	10	0.001	150	100	5.0	2.5	3.0^{t}	450	25	1.0	6.0	12	60
52	U309	10	0.001	150	100	5.0	2.5	3^{t}	450	25	1.0	4.0	12	30
52	U310	10	0.001	150	100	5.0	2.5	3^{t}	450	25	2.5	6.0	24	60
92	J308	12^{t}	100	250^{t}	100	7.5	2.5	1.5^{t}	100	25	1.0	6.5	12	60
92	J309	12^{t}	100	250^{t}	100	7.5	2.5	1.5^{t}	100	25	1.0	4.0	12	30
92	J310	12^{t}	100	250^{t}	100	7.5	2.5	1.5^{t}	100	25	2.0	6.5	24	60
72	MFE3004	2.0	0.001	—	—	4.5	0.4	4.5	200	20	—	−5.0	2.0	10
72	3N128*	5.0	0.001	500	200	7.0	0.28	5.0	200	−50	−0.5	−8.0	5.0	25

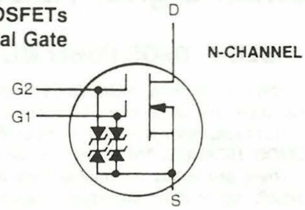
t = typical

*N-Channel MOSFET

MOSFETs (continued)
TABLE 4. Dual Gate MOSFETs

These devices are especially suited for RF amplifier and mixer applications in TV tuners, radio, etc. The Dual Gate construction also allows easy AGC control with very low power.

MOSFETs
Dual Gate



Dual Gate MOSFETs

Package TO –	Device	$R_e\|Y_{fs}\|$ (mmho) MIN	@ f (MHz)	$R_e\|Y_{os}\|$ (μmho) MAX	@ f (MHz)	C_{iss} (pF) (MAX)	C_{rss} (pF) MAX	NF (dB) MAX	NF @ RG = 1K f (MHz)	$V_{(BR)GSS}$ $V_{(BR)GDO}$ (V) MIN	$V_{GS(off)}$ (V) MIN	$V_{GS(off)}$ (V) MAX	I_{DSS} (mA) MIN	I_{DSS} (mA) MAX
72	MFE140	10	0.001			7.0	0.05	3.5	105	±7.0	—	4.0	3.0	30
72	MFE521	10	0.001			4.0	0.02	3.5	200	10	0.5	2.0	5.0	20
72	3N211	17	0.001			—	0.05	3.5	200	±6.0	−0.2	−5.5	6.0	40
M	MPF211	17	0.001			—	0.05	3.5	200	±6.0	−0.2	−5.5	6.0	40
72	3N206	7.0	0.001			—	0.03	4.0	45	25	−0.2	−4.0	3.0	15
72	3N213	15	0.001			—	0.05	4.0	45	±6.0	−0.2	−5.5	6.0	40
M	MPF213	15	0.001			—	0.05	4.0	45	±6.0	−0.2	−5.5	6.0	40
72	3N212	17	0.001			—	0.05	4.0	45	±6.0	−0.2	−4.0	6.0	40
M	MPF212	17	0.001			—	0.05	4.0	45	±6.0	−0.2	−4.0	6.0	40
72	3N203	7.0	0.001			4.3[t]	0.03	4.5	200	±6.0	−0.2	−5.0	3.0	11
M	MPF203	7.0	0.001			4.3[t]	0.03	4.5	200	±6.0	−0.2	−5.0	3.0	11
72	3N201	8.0	0.001			4.5[t]	0.03	4.5	200	±6.0	−0.2	−5.0	6.0	30
M	MPF201	8.0	0.001			4.3[t]	0.03	4.5	200	±6.0	−0.2	−5.0	6.0	30
72	3N202	8.0	0.001			4.3[t]	0.03	4.5	200	±6.0	−0.2	−5.0	6.0	30
M	MPF202	8.0	0.001			4.3[t]	0.03	4.5	200	±6.0	−0.2	−5.0	6.0	30
72	MFE121	10	0.001			6.0	0.02	5.0	60	±7.0	—	−4.0	5.0	30
72	MFE120	8.0	0.001			7.0	0.02	5.0	105	±7.0	—	−4.0	2.0	18
72	MFE130	8.0	0.001			7.0	0.05	5.0	105	±7.0	—	−4.0	3.0	30
72	MFE122	8.0	0.001			7.0	0.02	5.0	200	±7.0	—	−4.0	2.0	30
72	MFE131	8.0	0.001			7.0	0.05	5.0	200	±7.0	—	−4.0	3.0	30
72	MFE132	8.0	0.001			7.0	0.05	5.0	200	±7.0	—	−4.0	3.0	30
72	3N204	10	0.001			—	0.03	5.0	400	25	−0.2	−4.0	6.0	30
72	3N205	10	0.001			—	0.03	5.0	400	25	−0.2	−4.0	6.0	30
72	3N209	10	0.001			7.0	0.03	6.0	500	±7.0	−0.1	−4.0	5.0	30
M	MPF521	10	0.001			4.0	0.03	3.5	200	12	—	—	—	—

t = typical M = Macro-X Package

Small-Signal TMOS

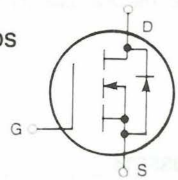
TABLE 5. TMOS Power MOSFETs

Power MOSFETs, Motorola trademark TMOS, are FET transistors with an oxide insulated gate which controls vertical current flow.

This basic description fits a number of structures and process titles including Vertical DMOS, HEXMOS, TMOS, UMOS, Vertical MOS, and VMOS.

There are subtle parametric tradeoffs with these different products but they all exhibit higher input impedance, faster switching, enhanced thermal stability, and easier paralleling than bipolar transistors. In addition, they have lower "on" resistance and higher power handling capability than conventional horizontal MOSFETs or JFETs.

TMOS



N-CHANNEL

N-Channel

Package TO –	Device	$r_{ds(on)}$ (Ω) MAX	@ I_D (A)	$V_{GS(th)}$ (V) MIN	$V_{GS(th)}$ (V) MAX	I_{DSS} (μA) MAX	$V_{(BR)DSS}$ (V) MIN	I_{GSS} (nA) MAX	C_{iss} (pF) MAX	C_{rss} (pF) MAX	t_{on} (ns) MAX	t_{off} (ns) MAX
39	MFE930	1.4	1.0	1.0	3.5	10	35	50	70	18	15	15
92	MPF930	1.4	1.0	1.0	3.5	10	35	50	70	18	15	15
39	MFE960	1.7	1.0	1.0	3.5	10	60	50	70	18	15	15
92	MPF960	1.7	1.0	1.0	3.5	10	60	50	70	18	15	15
39	MFE990	2.0	1.0	1.0	3.5	10	90	50	70	18	15	15
92	MPF990	2.0	1.0	1.0	3.5	10	90	50	70	18	15	15
18	MFE9200	6.4	.250	1.0	4.0	10	200	50	90	3.5	15	15
92	MPF9200	6.4	.250	1.0	4.0	10	200	50	90	3.5	15	15
92	BS107	14	0.20	1.0	2.6	0.03	200	10	90	3.5	15	15
92	BS170	5.0	0.20	0.8	3.0	0.5	60	10	38[t]	4.5[t]	10	10
226AE	MPF910	5.0	0.50	0.8	2.5	10	60	10	38[t]	4.5[t]	5.0[t]	5.0[t]
92	MPF6659	1.8	1.0	0.8	2.0	500	35	100	50	10	5.0	5.0
92	MPF6660	3.0	1.0	0.8	2.0	500	60	100	50	10	5.0	5.0
92	MPF6661	4.0	1.0	0.8	2.0	500	90	100	50	10	5.0	5.0
39	2N6659	1.8	1.0	0.8	2.0	10	35	100	50	10	5.0	5.0
39	2N6660	3.0	1.0	0.8	2.0	10	60	100	50	10	5.0	5.0
39	2N6661	4.0	1.0	0.8	2.0	10	90	100	50	10	5.0	5.0
226AE	MPF1010	—	—	0.3	2.5	10	100	10	35[t]	6[t]	5.0[t]	5.0[t]
39	MFE910	5.0	0.5	0.3	2.5	10	60	10	—	—	5.0[t]	5.0[t]

t = typical

GaAs FETs

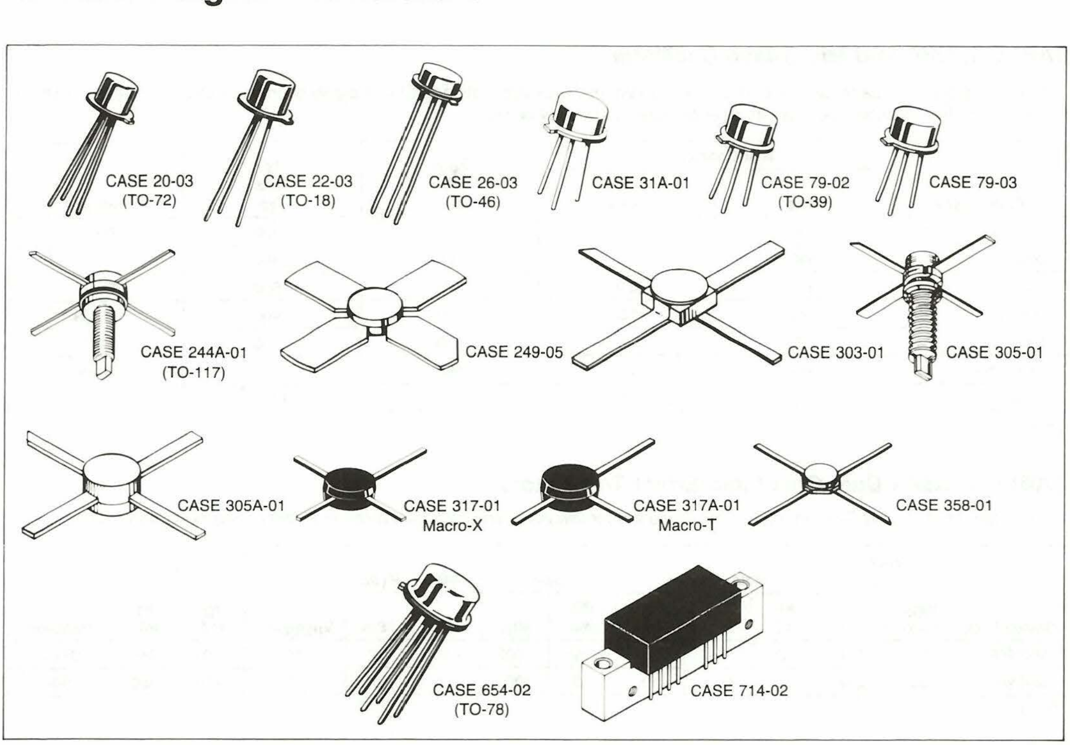
TABLE 6. GaAs Dual Gate Field-Effect Transistors

The GaAs Dual Gate FETs listed here are for low noise and high gain receiver amplifier and mixer applications.

Device Type	I_{DSS} Typ I_{DSS} (mA)	I_{DSS} Typ Vds	Noise Figure NF dB	Noise Figure f MHz	Noise Figure I_D mA	Gain dB Min	Gain f MHz	Ind_3 dB	MdB dBm	$V_{(BR)DSX}$	I_D mA	P_T mW	Package
MRF966	50	5.0	1.2*	1000	10	15	1000	−65*	10*	10	60	350	317-1
MRF967	50	5.0	1.2*	1000	10	13	1000	−65*	10*	10	60	350	358-1

*Typ

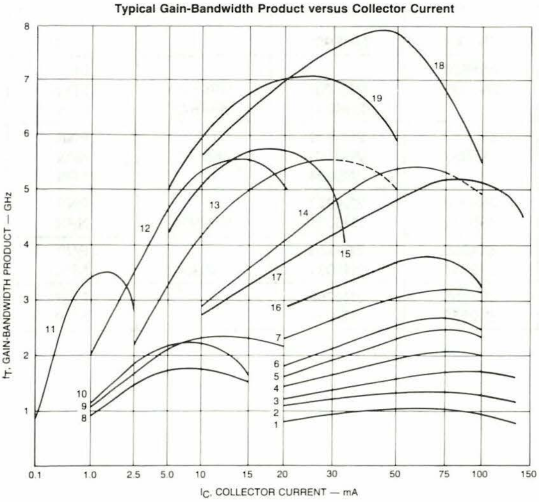
RF Small-Signal Transistors



Motorola's small-signal, low power RF transistor product range includes transistors with gain-bandwidths of 1.0 GHz to 8.0 GHz operating at currents of 0.25 mA to over 140 mA.

These devices are available in a wide variety of package types; metal can, plastic Macro-X and Macro-T, hermetic ceramic and microminiature. Most of these transistors are fully characterized with y or s parameters; and in addition, there are non-saturated switching characteristics, low power driver specifications, and noise figure limits. QPL types with JAN, JTX and JTXV processing levels are available as well as Hi Rel processing to meet unique customer requirements.

Typical Gain-Bandwidth Product versus Collector Current



RF Small-Signal Transistors

Motorola small-signal and medium power RF transistors with gain-bandwidth products from 1.0 GHz to 8.0 GHz operate with currents from 0.25 mA to over 140 mA. The following chart, combined with the tables of package options, enables the circuit designer to select the optimum device from Motorola's wide range of transistor/package combinations.

1 2N3866, 2N3866A, MM8000
2 2N5160, MM4018, PNP
3 2N3948, 2N4427, MRF207
4 2N5109, 2N5943, MM8001, MM8002
5 2N5583, PNP
6 2N5836, 2N5837
7 MRF511, MRF517, MRF525
8 2N2857, 2N3839, 2N5179, MRF501, MRF502
9 2N6304, 2N6305, BFX89, BFY90
10 2N4957, 2N4958, 2N4959, PNP
11 MRF931
12 2N6603, BFR90, MRF901, MRF904
13 2N6604, BFR91, MRF911, MRF914
14 BFR96, MRF961, MRF962, MRF965
15 BFW92A
16 MRF559
17 MRF580, MRF581, MRF586, MRF587
18 MRF571, MRF572, MRF573
19 MRF536, MRF534, MM4049, PNP

RF SMALL-SIGNAL TRANSISTORS (continued)

TABLE 1. UHF and Microwave Oscillators

The transistors listed below are for UHF and microwave oscillator applications as initial signal sources or as output stages of limited range transmitters. Devices are listed in order of increasing output power.

Device Type	Test Conditions f MHz	Test Conditions V_{CC} Volts	P_{out} mW Min	f_T MHz Typ	Package
2N5179	500	10	20	1800	TO-72
2N2857	500	10	30	1800	TO-72
2N3839	500	6.0	30	1800	TO-72
MM8009	1680	20	200	1400	TO-39
2N5108	1680	20	300	1400	TO-39
MRF905	1680	20	500*	2200	TO-46
2N3866	400	15	1000	1000	TO-39

*Typical

TABLE 2. GaAs Dual Gate Field-Effect Transistors

The GaAs Dual Gate N-Channel FET's listed here are for low noise and high gain receiver amplifier and mixer applications.

Device Type	I_{DSS} Typ I_{DSS} (mA)	I_{DSS} Typ Vds	Noise Figure NF dB	Noise Figure f MHz	Noise Figure I_D mA	Gain dB Min	Gain f MHz	IMD_3 dB	P_1dB dBm	$V_{(BR)DSX}$	I_D mA	P_T mW	Package
MRF966	50	5.0	1.2*	1000	10	15	1000	−65*	10*	10	60	350	317-1
MRF967	50	5.0	1.2*	1000	10	13	1000	−65*	10*	10	60	350	358-1

*Typical

TABLE 3. Low-Noise Transistors

The low-noise devices listed are produced with carefully controlled r_b' and f_T to optimize device noise performance. Devices listed in the matrix are classified according to noise figure performance versus frequency.

NF dB	Frequency MHz 60	100	200	450	1000	2000	Polarity
1.5	2N5829 2N5031	2N5829 2N5031	MRF904	MRF571	MRF572		PNP NPN
2.0	2N4957 2N5032	2N4957 2N5032	2N5829 2N5031	MRF904	MRF901		PNP NPN
2.5	2N4958 2N5032	2N4958 2N5032	2N4957 2N5032	2N5829 2N5031	MRF901 2N6603	MRF572 MRF573	PNP NPN NPN
3.0	2N4959 2N2857	2N4959 2N2857	2N4958 2N5032	2N4957 2N5032	2N5829 MRF901 2N6604	2N6603	PNP NPN NPN
3.5	2N4959 2N5179	2N4959 2N5179	2N4959 2N2857	2N4958 2N5032	2N4957 2N5031	MRF901	PNP NPN
4.0	2N4959 2N5179	2N4959 2N5179	2N4959 2N5179	2N4959 2N2857	2N4958 2N5031	2N6604	PNP NPN
4.5	2N4959 2N5179	2N4959 2N5179	2N4959 2N5179	2N4959 2N2857	2N4959 2N5032		PNP NPN

TABLE 4. CATV, MATV, and Class A Linear Transistors

The devices listed below are excellent for Class A linear CATV/MATV applications and are listed according to increasing gain-bandwidth (f_T). More information concerning the device for your specific linear design needs can be obtained through your local Motorola Sales Office or Motorola distributor.

Device Type	Nominal Test Conditions V_{CE}/I_C Volts/mA	f_T MHz Min	Noise Figure Max/Freq. dB/MHz	Distortion Specifications 2nd Order IMD	3rd Order IMD	12 Ch. Cross-Mod.	Output Level dBmV	Package
MRF501	6/5	600	4.5*/200					TO-72
MRF502	6/5	800	4.0*/200					TO-72
2N5179	6/5	900	4.5/200					TO-72
BFY90	5/2	1000	5.0/500					TO-72
2N6305	5/10	1200	5.5/450					TO-72
BFX89	5/25	1200	6.5/500					TO-72
2N5109	15/50	1200	3.0*/200					TO-39
2N5943	15/50	1200	3.4/200	−50		−42	+50	TO-39
2N6304	5/10	1400	4.5/450					TO-72
MRF511	20/80	1500	7.3*/200	−50	−65	−57	+50	244A-01
2N5947	20/75	1500*	3.8/200		−55	−60	+50	244A-01
MRF517	15/60	2200	7.5/300	−60	−72	−57	+45	TO-39
BFW92A	5/2	4500*	3.0*/500					317A-01
MRF586	14/70	4500*	3.0/500	−50	−72		+50	TO-39
BFR90	10/14	5000*	2.4*/500					317A-01
BFR91	5/35	5000*	1.9*/500					317A-01
BFR96	10/50	5000*	3.0*/500					317A-01
MRF961	10/50	5000*	2.0*/500					317-01
MRF962	10/50	5000*	2.0*/500					303-01
MRF965	10/50	5000*	2.0*/500					TO-46
MRF581	10/75	5000*	3.0/500		−65		+50	317-01
MRF587	14/70	5500*	3.0/500	−52	−72		+50	244A-01

*Typ

TABLE 5. High-Speed Switches

The transistors listed below are for use as high-frequency current-mode switches. They are also suitable for RF amplifier and oscillator applications. The devices are listed in ascending order of collector current.

Device Type	Test Conditions I_C/V_{CE} mA/Volts	f_T MHz Min	$r_b'C_C$ Max	Package
2N3959	10/10	1300	25	TO-18
2N3960	10/10	1600	40	TO-18
2N5835	10/6.0	2500	5.0**	TO-72
MM4049*	20/5.0	4000	15	TO-72
MRF914	20/10	4500**	—	TO-72
2N5842	25/4.0	1700	40	TO-72
2N5841	25/4.0	2200	25	TO-72
2N5943	50/15	1200	5.5**	TO-39
2N5583*	50/10	1000	8.0**	TO-39
2N5836	50/6.0	2000	6.0**	TO-46
2N5837	100/3.0	1700	6.0**	TO-46

*PNP **Typ

RF SMALL-SIGNAL TRANSISTORS (continued)

Class C Amplifiers

The transistors listed in these tables are specified for operation in Class C RF power amplifier circuits. The tables are arranged by increasing frequency of operation first, then by increasing output power. The first table contains those devices specified at 12.5 Vdc, while the following table contains devices specified at 28 Vdc.

TABLE 6. Low-Voltage Class C Amplifiers

Device Type	Frequency (MHz)	P_{in} (w)	P_{out} (w)	G_{pe} dB	Voltage (V)	Case Outline
MRF8003	27	0.05	0.5	10.0	12.5	TO-39
MRF8004	27	0.35	3.5	10.0	12.5	TO-39
MRF402	50	0.1	1.0	10.0	12.5	TO-39
MRF229	90	0.15	1.5	10.0	12.5	TO-39
MRF230	90	0.15	1.5	10.0	12.5	TO-39
MRF604	175	0.1	1.0	10.0	12.5	TO-46
2N4427	175	0.1	1.0	10.0	12.0	TO-39
MRF607	175	0.12	1.75	11.5	12.5	TO-39
2N6255	175	0.5	3.0	7.8	12.5	TO-39
MRF237*	175	0.25	4.0	12.0	12.5	TO-39
MRF207	220	0.15	1.0	8.2	12.5	TO-39
MRF225	225	0.18	1.5	9.0	12.5	TO-39
MRF227*	225	0.13	3.0	13.5	12.5	TO-39
2N3948	400	0.25	1.0	6.0	13.6	TO-39
2N6256	470	0.1	0.5	7.0	12.5	249-5
MRF515	470	0.12	0.75	8.0	12.5	TO-39
MRF581	470	0.05	1.2	13.8	12.5	317-1
MRF629*	470	0.32	2.0	8.0	12.5	TO-39
MRF626	470	0.05	0.5	10.0	12.5	305-1
MRF627	470	0.05	0.5	10.0	12.5	305A-1
MRF628	470	0.05	0.5	10.0	12.5	249-5
MRF630	470	0.25	3.0	10.8	12.5	TO-39
MRF559	870	0.063	0.5	9.0	12.5	317-1
MRF581	870	0.12	1.0	9.2	12.5	317-1

TABLE 7. High-Voltage Class C Amplifiers

Device Type	Frequency (MHz)	P_{in} (w)	P_{out} (w)	G_{pe} dB	Voltage (V)	Case Outline
2N3553	175	0.25	2.5	10.0	28.0	TO-39
MRF525*	400	0.001	0.02	13.0	26.0	TO-39
2N3866	400	0.1	1.0	10.0	28.0	TO-39
2N5160†	400	0.16	1.0	8.0	28.0	TO-39
MRF313	400	0.03	1.0	15.0	28.0	305A-1
MRF313A	400	0.03	1.0	15.0	28.0	305-1

*Grounded Emitter TO-39
†PNP

Small-Signal Amplifier Transistor Selection by Package

In small-signal RF applications the package style is often determined by the end application, or circuit construction technique. To aid the circuit designer in device selection, below are listed the Motorola broad range of RF small-signal amplifier transistors organized by package. Devices for other applications such as oscillators or switches are shown in the appropriate preceding tables.

TABLE 8. TO-39 METAL CAN

	Gain — BW		Noise Figure			Gain		Maximum Ratings		
Device Type	f_T GHz	I_C mA	NF dB	f MHz	I_C mA	dB Min	f MHz	$V_{(BR)CEO}$ V	I_C mA	P_T mW
MM8000	0.7	50	2.7	200	10	11.4*	200	30	0.4	3.50
MM8001	0.9	50	2.7	200	10	11.4*	200	30	0.4	3.50
2N5109	1.2	50	3.0	200	10	11	216	20	400	2.50
2N5943	1.2	50	3.4	200	30	11.4*	200	30	400	3.50
MRF525†	2.5	50	4.0	400	—	13	400	35**	150	2.50
MRF517	2.7	60	7.5	300	50	10*	300	35**	150	2.50
MRF586	4.5	70	3.0	500	70	14*	500	17	200	2.50

†Grounded Emitter TO-39 *Typ **$V_{(BR)CBO}$

TABLE 9. Plastic — SOE — Case 317-01/317A-01

	Gain — BW		Noise Figure			Gain		Maximum Ratings		
Device Type	f_T GHz	I_C mA	NF dB	f MHz	I_C mA	dB Min	f MHz	$V_{(BR)CEO}$ V	I_C mA	P_T mW
MRF931	3.0	1.0	3.8	500	0.25	16*	500	5.0	5.0	50
MRF559	3.0	100	—	—	—	13.0*	512	18	150	2000
BFW92A	4.0	25	2.5	500	2.0	16*	500	5.0	50	190
MRF901	4.5	15	2.0	1000	5.0	10	1000	15	30	375
BFR96	4.5	50	2.0*	500	10	12	500	15	100	500
MRF961	4.5	50	2.0*	500	10	13.5	500	15	100	500
MRF911	5.0	30	2.5	1000	5.0	12.5*	1000	12	40	400
BFR90	5.0	14	2.4	500	2.0	18*	500	15	30	180
BFR91	5.0	30	1.9	500	2.0	16*	500	12	35	180
MRF571	8.0	5.0	1.0*	500	5.0	13.5	500	10	70	2500
MRF580	5.0	75	2.0*	500	50.0	11.0	500	18	200	2500
MRF581	5.0	75	2.0*	500	50.0	13.0	500	18	200	2500
MRF536**	5.0	20	4.5*	1000	3.0	8.5	1000	10	30	300

*Typ **PNP

TABLE 10. Ceramic — SOE — Case 244A-01, 303-01, 358-01

	Gain — BW		Noise Figure			Gain		Maximum Ratings		
Device Type	f_T GHz	I_C mA	NF dB	f MHz	I_C mA	dB Min	f MHz	$V_{(BR)CEO}$ V	I_C mA	P_T mW
2N5947	1.5	75	3.8	200	50	10	250	30	400	5000
MRF511	2.1	80	7.3	200	50	10	250	25	250	5000
2N6603	4.5	15	2.0	1000	5.0	13*	1000	15	30	400
MRF962	4.5	50	2.0*	500	10	15	500	15	100	750
2N6604	5.0	30	2.5	1000	5.0	14	1000	12	50	500
MRF587	5.5	70	3.0	500	70	15*	500	17	200	5800
MRF572	8.0	50	2.0	1000	5.0	10	1000	10	70	2500
MRF573	8.0	50	2.0	1000	5.0	10	1000	10	70	2500

*Typ

RF SMALL-SIGNAL TRANSISTORS (continued)

TABLE 11. TO-72 METAL CAN

	Gain — BW		Noise Figure			Gain		Maximum Ratings		
Device Type	f_T GHz	I_C mA	NF dB	f MHz	I_C mA	dB Min	f MHz	$V_{(BR)CEO}$ V	I_C mA	P_T mW
2N5031	1.0	5.0	2.5	450	1.0	14	450	10	20	200
2N5032	1.0	5.0	3.0	450	1.0	14	450	10	20	200
2N4958*	1.0	2.0	3.3	450	2.0	16	450	30	30	200
2N4959*	1.0	2.0	3.8	450	2.0	15	450	30	30	200
2N5829*	1.2	2.0	2.5	450	2.0	17	450	30	30	200
2N4957*	1.2	2.0	3.0	450	2.0	17	450	30	30	200
MRF501	1.2	5.0	4.0	200	1.5	15**	200	15	50	200
MRF502	1.2	5.0	4.0	200	1.5	15**	200	15	50	200
2N6305	1.2	10	5.5	450	2.0	12	450	15	50	200
BFX89	1.2	25	6.5	500	2.0	19	200	15	50	200
BFY90	1.4	25	5.0	500	2.0	21	200	15	50	200
2N5179	1.4	10	4.5	200	1.5	15	200	12	50	200
2N6304	1.4	10	4.5	450	2.0	15	450	15	50	200
2N3839	1.6	8.0	3.9	450	1.5	12.5	450	15	40	200
2N2857	1.6	8.0	4.1	450	1.5	12.5	450	15	40	200
MRF904	4.0	15	1.5	450	5.0	16	450	15	30	200
MRF914	4.5	20	2.0	500	5.0	15	500	12	40	200

*PNP **Typ

RF Amplifier Modules

The devices listed below are general purpose RF hybrid amplifiers, which feature input and output impedance matching and dc biasing networks for simplified RF amplifier design.

TABLE 12. General-Purpose 50 Ω — 100 Ω Wideband Modules

Device Type	Frequency Range MHz	Gain dB Min/Typ	Supply Voltage Vdc	Output Level 1 dB Compression mW/f (MHz)	Noise Figure @ 250 MHz dB
MHW590	10-400	32.5/34	24	800/200	5.0
MHW591	1.0-250	35/36.5	13.6	700/100	5.0
MHW592	1.0-250	34.5/36	24	900/100	5.0
MHW593	10-400	34/35.5	13.6	600/200	4.5

TABLE 13. TO-39 Wideband, 50 Ω Modules

The MWA Series features excellent gain versus frequency flatness, temperature stability and are cascadable for high gain lineups. Construction techniques include thin film gold metal circuitry and hermetic TO-39 package. MWA devices processed for military applications are available to special order.

Device Type	Frequency Range MHz	Gain dB Min/Typ	Supply Voltage Vdc	Output Level 1 dB Compression dBm Typ	Noise Figure (400 MHz) dB Typ
MWA110	0.1-400	13/14	2.9	−2.5	4.0
MWA120	0.1-400	13/14	5.0	+8.2	5.5
MWA130	0.1-400	13/14	5.5	+18	7.0
MWA210	0.1-600	9/10	1.75	+1.5	6.0
MWA220	0.1-600	9/10	3.2	+10.5	6.5
MWA230	0.1-600	9/10	4.4	+18.5	7.5
MWA310	0.1-1000	7/8	1.60	+3.5	6.5
MWA320	0.1-1000	7/8	2.9	+11.5	6.7
MWA330	0.1-1000	—/6.2	4.0	+15.2	9.0

High Reliability RF Transistors

The listed devices are active per QPL-19500 (Qualified Products List). Check with your local Motorola Sales Office or franchised Distributor for current qualification status and additions.

2N2857JAN	2N4957JAN
2N2857JTX	2N4957JTX
2N2857JTXV	2N4957JTXV
2N3553JAN	2N5109JAN
2N3553JTX	2N5109JTX
2N3553JTXV	2N5109JTXV
2N3866JAN	2N6603JAN
2N3866JTX	2N6603JTX
2N3866JTXV	2N6603JTXV
2N3866AJAN	2N6604JAN
2N3866AJTX	2N6604JTX
2N3866AJTXV	2N6604JTXV
2N3960JAN	
2N3960JTX	
2N3906JTXV	

Transistor Complements

The transistor complements listed are suitable for most applications requiring NPN and PNP devices of similar RF characteristics. If your application demands special matching of complementary transistors, please contact your local Motorola Sales Office or Motorola distributors.

NPN	PNP
2N2857	2N4958
2N3553	MM4019
2N3866	2N5160
2N3959, 2N3960	2N4260, 2N4261
2N3906JAN	MM4261H
2N5943	2N5583
MRF531	MRF532
MRF904	MM4049
MRF571	MRF536

Devices for Hi-Rel Applications

Motorola offers over 650 devices listed in QPL-19500, and is certified to supply small-signal bipolar devices to ALL FOUR quality levels of MIL-S-19500: JAN, JANTX, JANTXV, and JANS.

The following tables list the Motorola discrete devices and slash-sheet number as they appear on the Qualified Products List.

Switching and High-Frequency Transistors

MIL-S-19500

2N703 JAN	/153
2N706 JAN	/120
2N708 JAN,JTX	/312
2N718A JAN,JTX,JTXV	/181
2N869A JAN,JTX	/283
2N914 JAN,JTX	/373
2N916 JAN	/271
2N918 JAN,JTX,JTXV,JANS	/301
2N930 JAN,JTX	/253
2N1132 JAN	/177
2N1613 JAN,JTX,JTXV	/181
2N2218 JAN,JTX,JTXV	/251
2N2218A JAN,JTX,JTXV	/251
2N2219 JAN,JTX,JTXV	/251
2N2219A JAN,JTX,JTXV	/251
2N22219AL JANS	/
2N2221 JAN,JTX,JTXV	/255
2N2221A JAN,JTX,JTXV	/255
2N2222 JAN,JTX,JTXV	/255
2N2222A JAN,JTX,JTXV,JANS	/225
2N2369A JAN,JTX,JTXV,JANS	/317
2N2481 JAN,JTX	/268
2N2904 JAN,JTX,JTXV	/290
2N2904A JAN,JTX,JTXV	/
2N2905 JAN,JTX,JTXV	/290
2N2905A JAN,JTX,JTXV	/290
2N2905AL JANS	/
2N2906 JAN,JTX,JTXV	/291
2N2906A JAN,JTX,JTXV	/291
2N2907 JAN,JTX,JTXV	/291
2N2907A JAN,JTX,JTXV,JANS	/291
2N2944A JAN,JTX,JTXV	/
2N2945A JAN,JTX,JTXV	/
2N2946A JAN,JTX,JTXV	/
2N3013 JAN,JTX	/287
2N3019,S JAN,JTX,JTSV	/391
2N3250A JAN,JTX,JTXV	/323
2N3251A JAN,JTX,JTXV	/323
2N3253 JAN	/347
2N3444 JAN,JTX	/347
2N3467 JAN,JTX,JTXV	/348
2N3468 JAN,JTX,JTXV	/348
2N3485A JAN,JTX	/392
2N3486A JAN,JTX	/392
2N3498 JAN,JTX,JTXV	/366
2N3499 JAN,JTX,JTXV	/366
2N3500 JAN,JTX,JTXV	/366
2N3501 JAN,JTX,JTXV	/366
2N3506 JAN,JTX,JTXV	/349
2N3507 JAN,JTX,JTXV	/349
2N3634 JAN,JTX,JTXV	/357
2N3635 JAN,JTX,JTXV	/357
2N3636 JAN,JTX,JTXV	/357
2N3637 JAN,JTX,JTXV	/357
2N3700 JAN,JTX,JTXV	/391
2N3735 JAN,JTX,JTXV	/395
2N3737 JAN,JTX,JTXV	/395
2N3743 JAN,JTX,JTXV	/397
2N3762 JAN,JTX,JTXV	/396
2N3763 JAN,JTX,JTXV	/396
2N3764 JAN,JTX,JTXV	/396
2N3765 JAN,JTX,JTXV	/396
2N4033 JAN,JTX,JTXV	/511
2N4261 JAN,JTX,JTXV	/511
2N4405 JAN,JTX,JTXV	/488
2N4449 JAN,JTX,JTXV	/317
2N4453 JAN,JTX	/283
2N4930 JAN,JTX,JTXV	/397
2N4931 JAN,JTX,JTXV	/397
2N5581 JAN,JTX	/423
2N5582 JAN,JTX	/423

RF Transistors

MIL-S-19500

2N918 JAN,JTX,JTXV,JANS	/301
2N2857 JAN,JTX,JTXV	/343
2N3375 JAN,JTX,JTXV	/341
2N3553 JAN,JTX,JTXV	/341
2N3866 JAN,JTX,JTXV	/398
2N3866A JAN,JTX,JTXV	/398
2N3959 JAN,JTX,JTXV	/399
2N3960 JAN,JTX,JTXV	/399
2N4957 JAN,JTX,JTXV	/426
2N5109 JAN,JTX,JTXV	/453
2N6603 JAN,JTXV	/522
2N6604 JAN,JTXV	/522

Multiple Devices

MIL-S-19500

2N2060 JAN,JTX,JTXV	/270
2N2919 JAN,JTX,JTXV	/355
2N2920 JAN,JTX,JTXV	/355
2N3810 JAN,JTX,JTXV	/336
2N3811 JAN,JTX,JTXV	/336
2N4854 JAN,JTX,JTXV	/421
2N5793 JAN,JTX,JTXV	/495
2N5794 JAN,JTX,JTXV	/495
2N5795 JAN,JTX,JTXV	/496
2N5796 JAN,JTX,JTXV	/496

Field-Effect Transistors

MIL-S-19500

2N2608 JAN	/295
2N2609 JAN	/296
2N3330 JAN,JTX	/378
2N3821 JAN,JTX,JTXV	/375
2N3822 JAN,JTX,JTXV	/375
2N3823 JAN,JTX,JTXV	/375
2N4856 JAN,JTX,JTXV	/385
2N4857 JAN,JTX,JTXV	/385
2N4858 JAN,JTX,JTXV	/385
2N4859 JAN,JTX,JTXV	/385
2N4860 JAN,JTX,JTXV	/385
2N4861 JAN,JTX,JTXV	/385
2N4091 JAN,JTX,JTXV	/431
2N4092 JAN,JTX,JTXV	/431
2N4093 JAN,JTX,JTXV	/431

Plastic-Encapsulated Small-Signal Transistors

2


CASE 29-02
TO-92


CASE 29-03
1 WATT TO-92

Motorola's small-signal TO-92 plastic transistors encompass hundreds of devices spanning the gamut from general-purpose amplifiers and switches with a wide variety of characteristics to dedicated special-purpose devices for the most demanding applications. The popular high-volume TO-92 package combines proven reliability, performance, economy and convenience to provide the perfect solution for industrial and consumer design problems.

As an additional service to our customers Motorola will, upon request, supply the following:

- Radial tape and reel
- Axial tape and reel
- TO-5 lead forming
- TO-18 lead forming

Contact your Motorola representative for ordering information.

2N3903
2N3904

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltge	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 2.8	mW mW/°C
*Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

*Indicates Data in addition to JEDEC Requirements.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)		$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	6.0	—	Vdc
Base Cutoff Current ($V_{CE} = 30$ Vdc, $V_{EB} = 3.0$ Vdc)		I_{BL}	—	50	nAdc
Collector Cutoff Current ($V_{CE} = 30$ Vdc, $V_{EB} = 3.0$ Vdc)		I_{CEX}	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain(1)		h_{FE}			—
($I_C = 0.1$ mAdc, $V_{CE} = 1.0$ Vdc)	2N3903 2N3904		20 40	— —	
($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc)	2N3903 2N3904		35 70	— —	
($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)	2N3903 2N3904		50 100	150 300	
($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc)	2N3903 2N3904		30 60	— —	
($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)	2N3903 2N3904		15 30	— —	
Collector-Emitter Saturation Voltage(1) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{CE(sat)}$	 — —	 0.2 0.3	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{BE(sat)}$	 0.65 —	 0.85 0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	 2N3903 2N3904	f_T	 250 300	 — —	MHz

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	8.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3903 2N3904	h_{ie}	1.0 1.0	8.0 10	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3903 2N3904	h_{re}	0.1 0.5	5.0 8.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3903 2N3904	h_{fe}	50 100	200 400	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	1.0	40	µmhos
Noise Figure (I_C = 100 µAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohms, f = 10 Hz to 15.7 kHz)	2N3903 2N3904	NF	— —	6.0 5.0	dB

SWITCHING CHARACTERISTICS

Characteristic	Conditions		Symbol	Min	Max	Unit
Delay Time	(V_{CC} = 3.0 Vdc, V_{BE} = 0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)		t_d	—	35	ns
Rise Time			t_r	—	35	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	2N3903 2N3904	t_s	— —	175 200	ns
Fall Time			t_f	—	50	ns

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

FIGURE 1 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

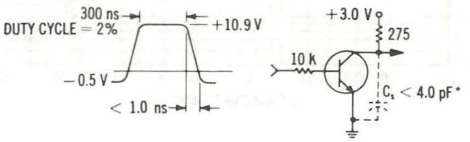
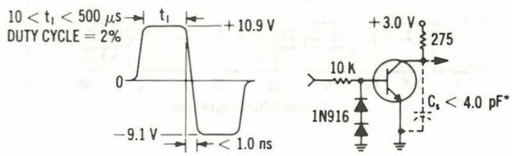


FIGURE 2 – STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



*Total shunt capacitance of test jig and connectors

TYPICAL TRANSIENT CHARACTERISTICS

— T_J = 25°C - - - T_J = 125°C

FIGURE 3 – CAPACITANCE

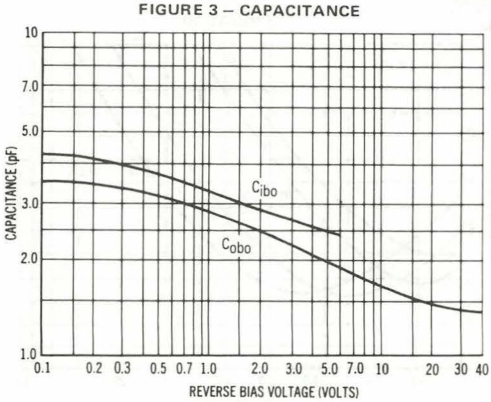


FIGURE 4 – CHARGE DATA

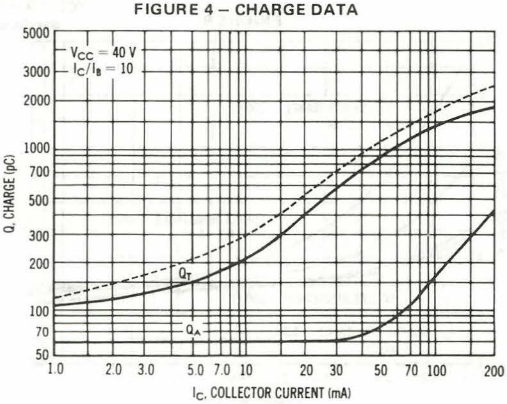


FIGURE 5 — TURN-ON TIME

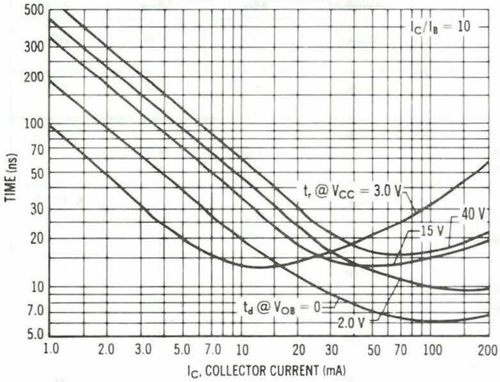


FIGURE 6 — RISE TIME

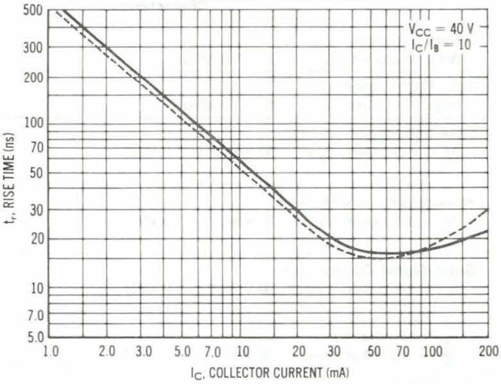


FIGURE 7 — STORAGE TIME

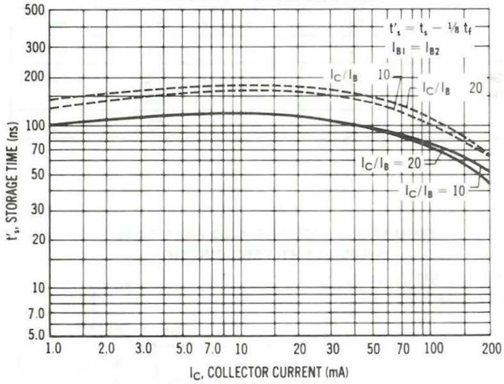
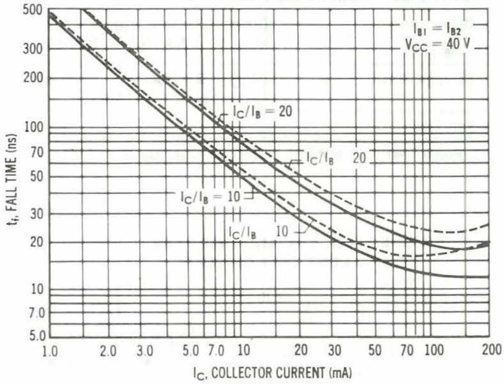


FIGURE 8 — FALL TIME



TYPICAL AUDIO SMALL-SIGNAL CHARACTERISTICS
NOISE FIGURE VARIATIONS

V_{CE} = 5.0 Vdc, T_A = 25°C,
Bandwidth = 1.0 Hz

FIGURE 9

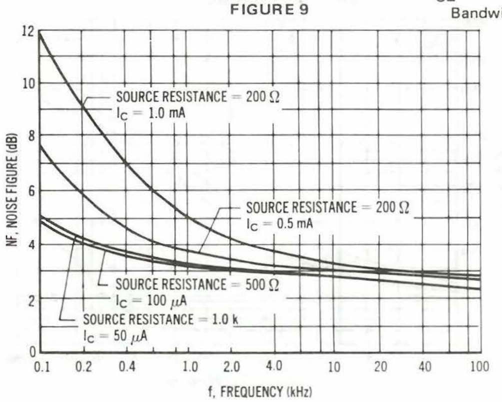
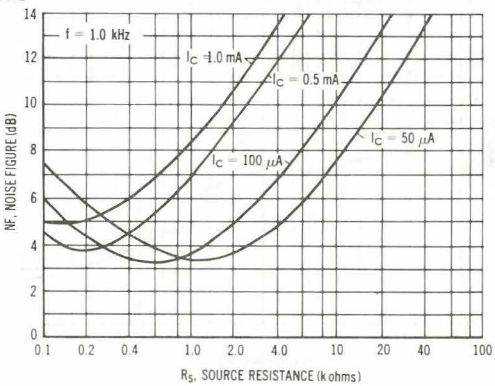


FIGURE 10



h PARAMETERS

(V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C)

FIGURE 11 – CURRENT GAIN

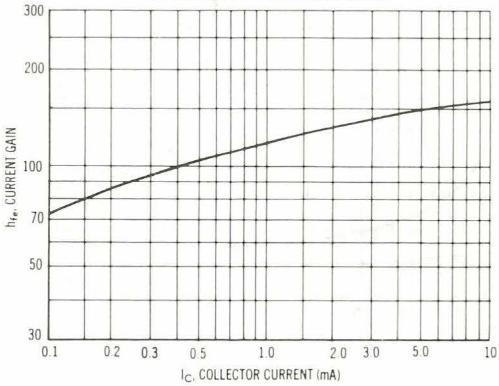


FIGURE 12 – OUTPUT ADMITTANCE

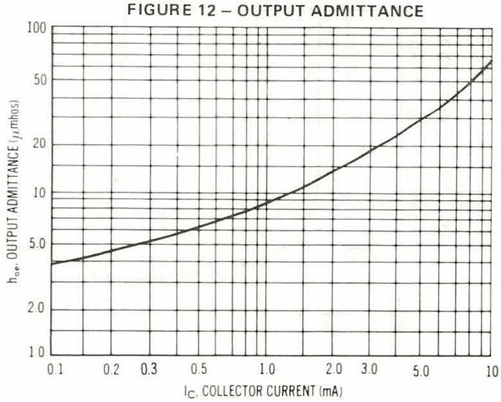


FIGURE 13 – INPUT IMPEDANCE

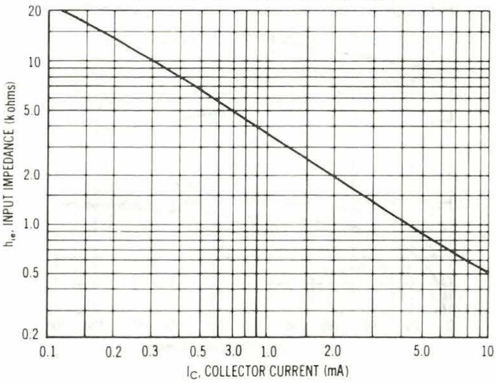
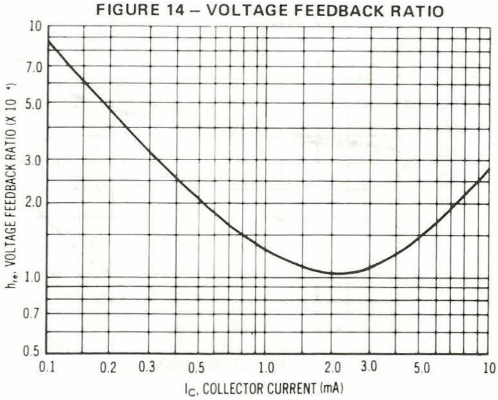


FIGURE 14 – VOLTAGE FEEDBACK RATIO



TYPICAL STATIC CHARACTERISTICS

FIGURE 15 – DC CURRENT GAIN

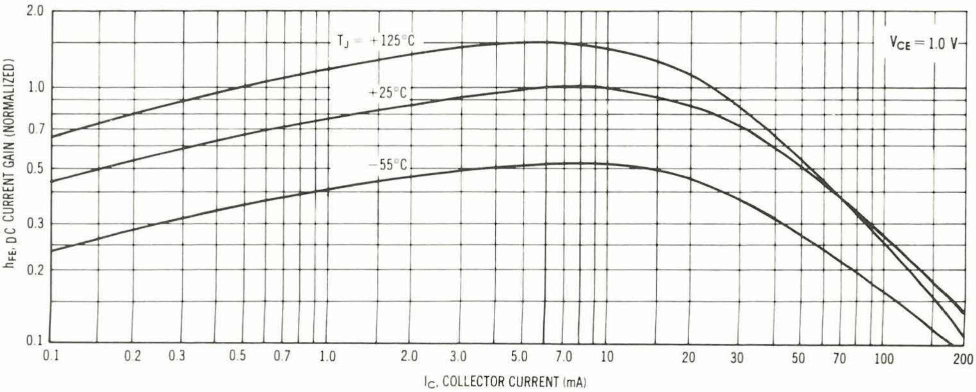


FIGURE 16 – COLLECTOR SATURATION REGION

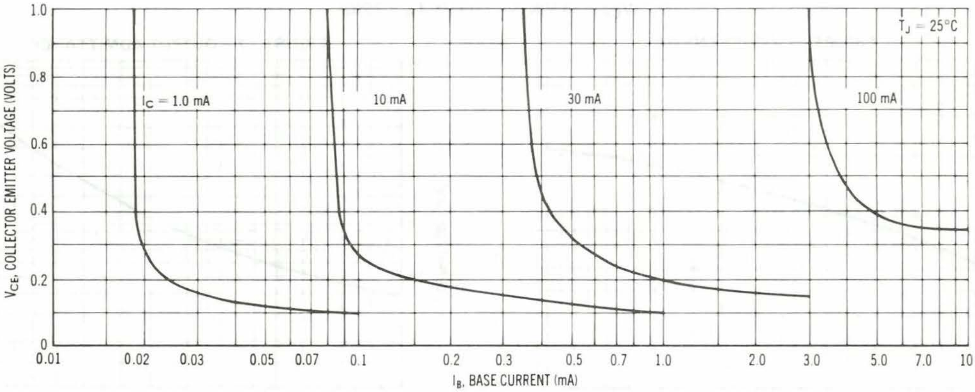


FIGURE 17 – "ON" VOLTAGES

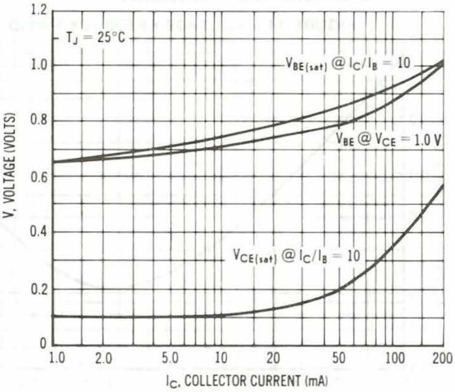
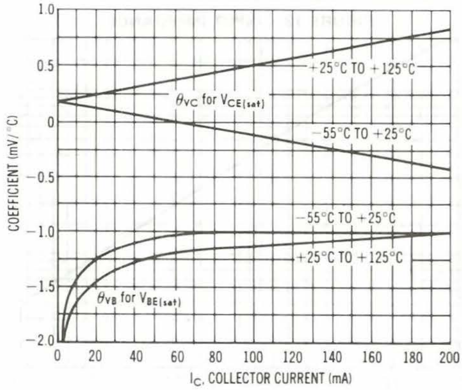


FIGURE 18 – TEMPERATURE COEFFICIENTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Power Dissipation @ $T_A = 60°C$	P_D	250	mW
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

***THERMAL CHARACTERISTICS**

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

2N3905
2N3906

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

2

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)		$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Base Cutoff Current ($V_{CE} = 30$ Vdc, $V_{BE} = 3.0$ Vdc)		I_{BL}	—	50	nAdc
Collector Cutoff Current ($V_{CE} = 30$ Vdc, $V_{BE} = 3.0$ Vdc)		I_{CEX}	—	50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain		h_{FE}			—
($I_C = 0.1$ mAdc, $V_{CE} = 1.0$ Vdc)	2N3905 2N3906		30 60	— —	
($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc)	2N3905 2N3906		40 80	— —	
($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)	2N3905 2N3906		50 100	150 300	
($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc)	2N3905 2N3906		30 60	— —	
($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)	2N3905 2N3906		15 30	— —	
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{CE(sat)}$	 — —	 0.25 0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{BE(sat)}$	 0.65 —	 0.85 0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	 2N3905 2N3906	f_T	 200 250	 — —	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 100 kHz)		C_{obo}	—	4.5	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	10.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3905 2N3906	h_{ie}	0.5 2.0	8.0 12	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3905 2N3906	h_{re}	0.1 0.1	5.0 10	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3905 2N3906	h_{fe}	50 100	200 400	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3905 2N3906	h_{oe}	1.0 3.0	40 60	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohm, f = 10 Hz to 15.7 kHz)	2N3905 2N3906	NF	— —	5.0 4.0	dB

SWITCHING CHARACTERISTICS

Characteristic	Conditions		Symbol	Min	Max	Unit
Delay Time	(V_{CC} = 3.0 Vdc, V_{BE} = 0.5 Vdc I_C = 10 mAdc, I_{B1} = 1.0 mAdc)		t_d	—	35	ns
Rise Time			t_r	—	35	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	2N3905 2N3906	t_s	— —	200 225	ns
Fall Time		2N3905 2N3906	t_f	— —	60 75	ns

(1) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

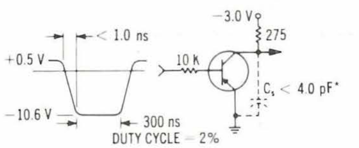
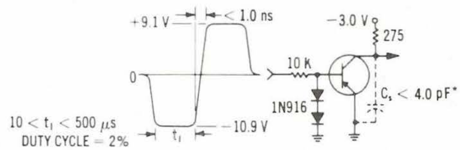


FIGURE 2 — STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



*Total shunt capacitance of test jig and connectors

TRANSIENT CHARACTERISTICS

—— T_J = 25°C - - - T_J = 125°C

FIGURE 3 — CAPACITANCE

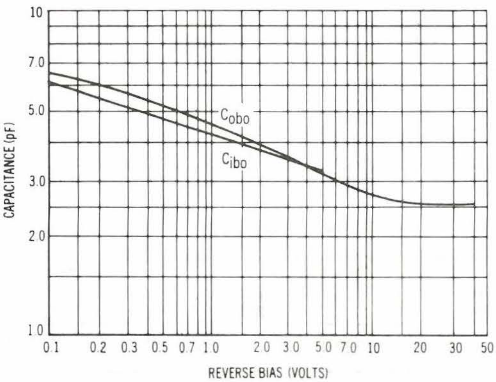


FIGURE 4 — CHARGE DATA

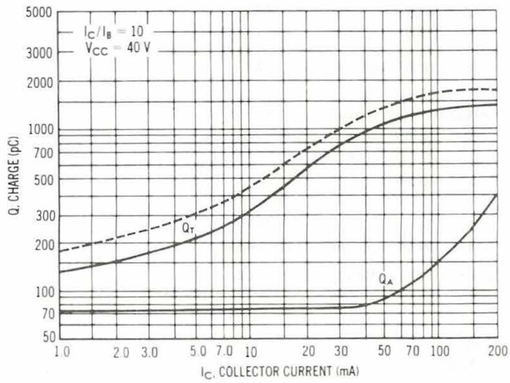


FIGURE 5 — TURN-ON TIME

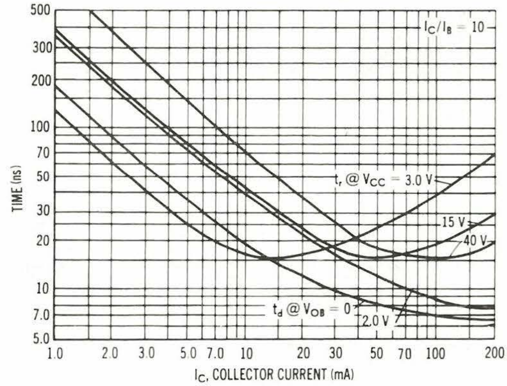
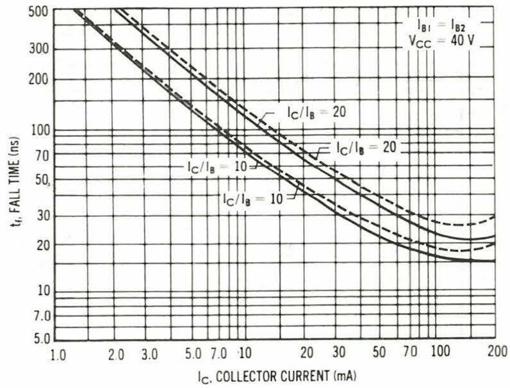


FIGURE 6 — FALL TIME



AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE VARIATIONS

V_{CE} = 5.0 Vdc, T_A = 25°C,
Bandwidth = 1.0 Hz

FIGURE 7 —

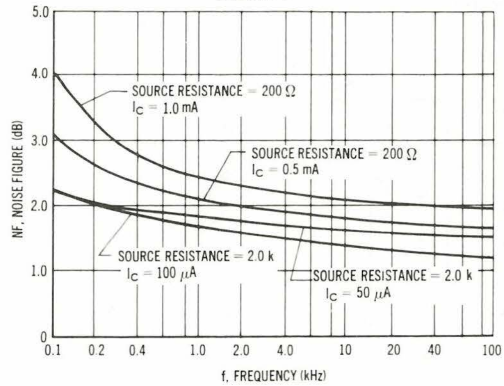
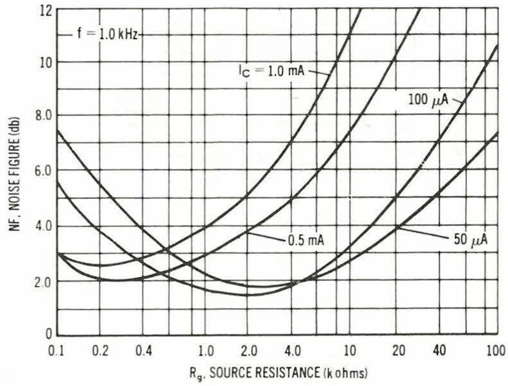


FIGURE 8 —



h PARAMETERS

(V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C)

FIGURE 9 — CURRENT GAIN

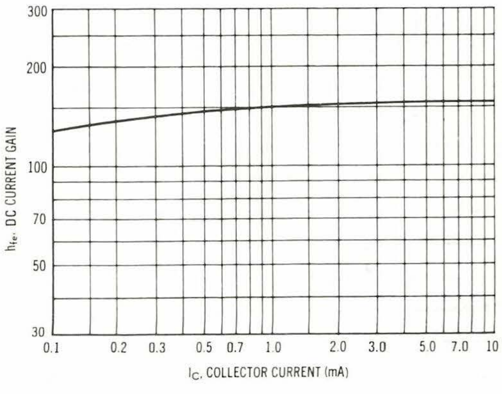
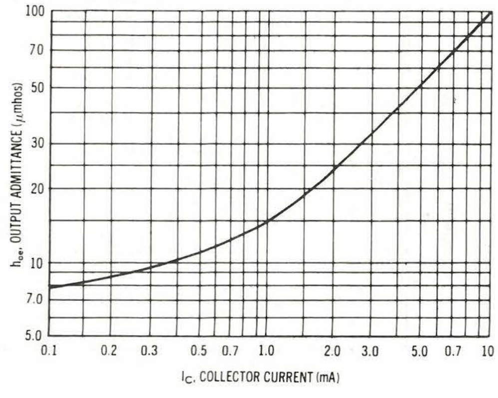


FIGURE 10 — OUTPUT ADMITTANCE



2

FIGURE 11 — INPUT IMPEDANCE

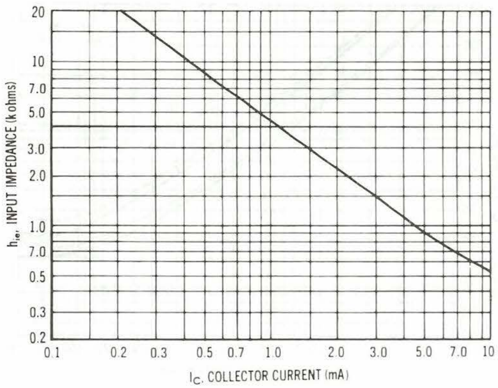
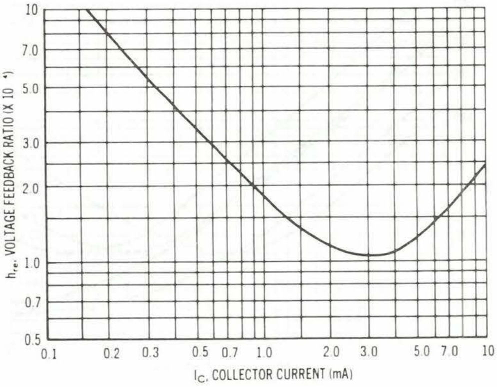


FIGURE 12 — VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 13 — DC CURRENT GAIN

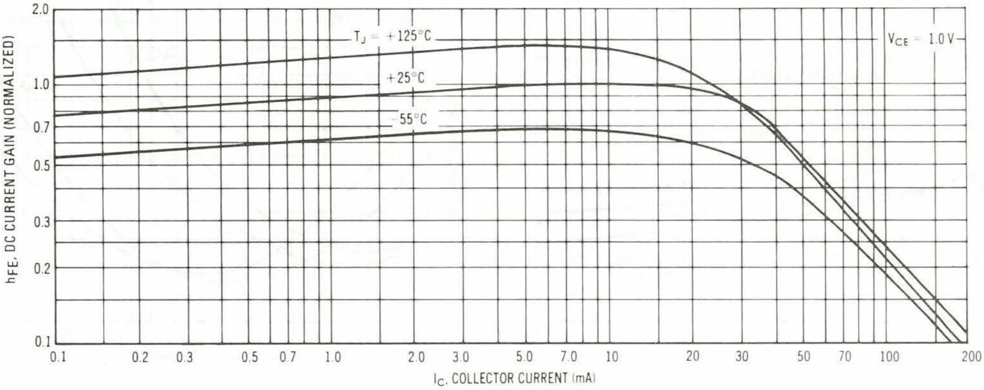


FIGURE 14 — COLLECTOR SATURATION REGION

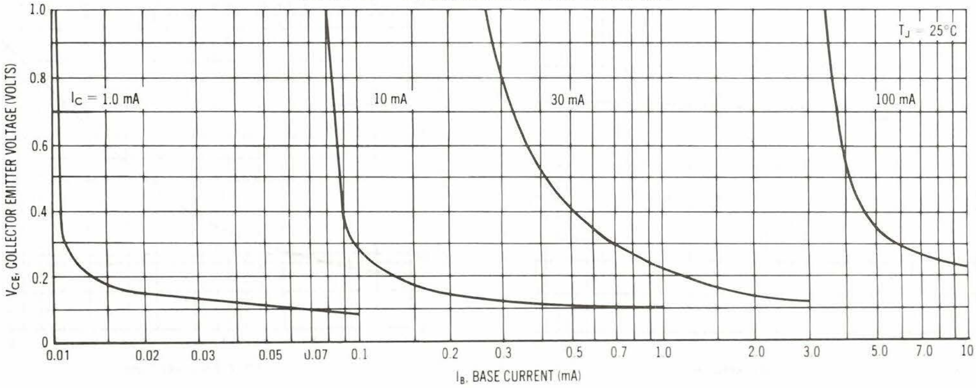


FIGURE 15 — "ON" VOLTAGES

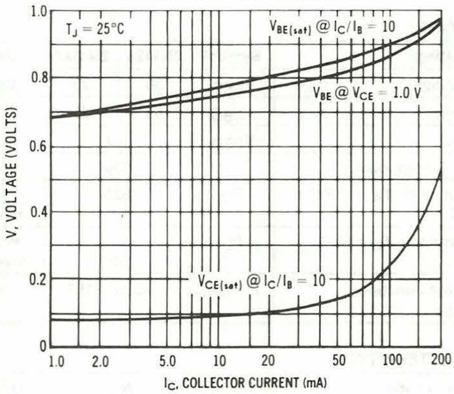
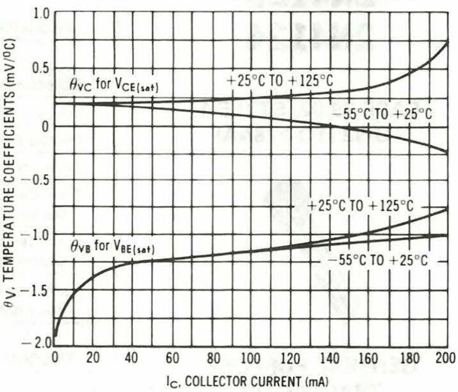


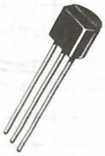
FIGURE 16 — TEMPERATURE COEFFICIENTS



2

2N4123
2N4124

CASE 29-02, STYLE 1
TO-92 (TO-226AA)



GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N4123	2N4124	Unit
Collector-Emitter Voltage	V_{CEO}	30	25	Vdc
Collector-Base Voltage	V_{CBO}	40	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_E = 0$)	2N4123 2N4124	$V_{(BR)CEO}$	30 25	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	2N4123 2N4124	$V_{(BR)CBO}$	40 30	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)		I_{CBO}	—	50	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) ($I_C = 2.0$ mAdc, $V_{CE} = 1.0$ Vdc)	2N4123 2N4124	h_{FE}	50 120	150 360	—
($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc)	2N4123 2N4124		25 60	— —	
Collector-Emitter Saturation Voltage(1) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{CE(sat)}$	—	0.3	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{BE(sat)}$	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	2N4123 2N4124	f_T	250 300	— —	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 100 MHz)		C_{obo}	—	4.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)		C_{ibo}	—	8.0	pF
Collector-Base Capacitance ($I_E = 0$, $V_{CB} = 5.0$ V, f = 100 kHz)		C_{cb}	—	4.0	pF
Small-Signal Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	2N4123 2N4124	h_{fe}	50 120	200 480	—

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Current Gain — High Frequency (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N4123 2N4124	$\|h_{fe}\|$	2.5 3.0	— —	—
(I_C = 2.0 mAdc, V_{CE} = 10 V, f = 1.0 kHz) (I_C = 2.0 mAdc, V_{CE} = 10 V, f = 1.0 kHz)	2N4123 2N4124		50 120	200 480	
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kohm, Noise Bandwidth = 10 Hz to 15.7 kHz)	2N4123 2N4124	NF	— —	6.0 5.0	dB

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

FIGURE 1 — CAPACITANCE

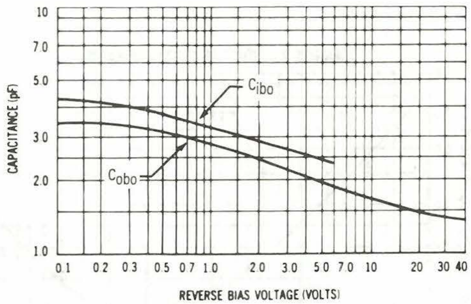
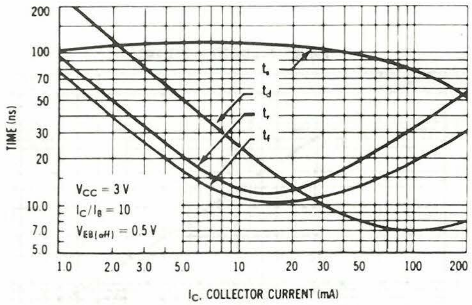


FIGURE 2 — SWITCHING TIMES



AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE

(V_{CE} = 5 Vdc, T_A = 25°C)
Bandwidth = 1.0 Hz

FIGURE 3 — FREQUENCY VARIATIONS

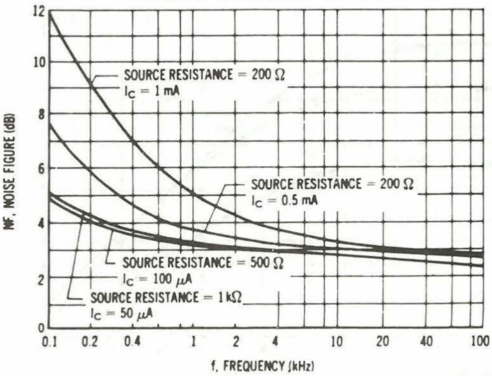
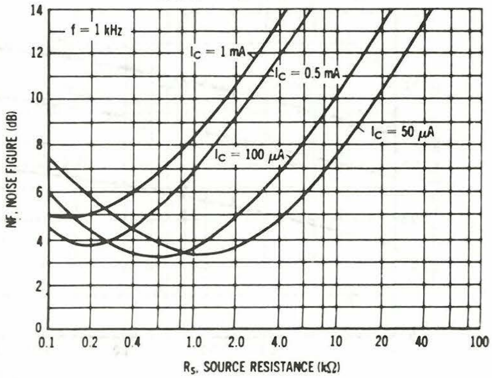


FIGURE 4 — SOURCE RESISTANCE



2

h PARAMETERS

$V_{CE} = 10\ V$, $f = 1\ kHz$, $T_A = 25°C$

FIGURE 5 — CURRENT GAIN

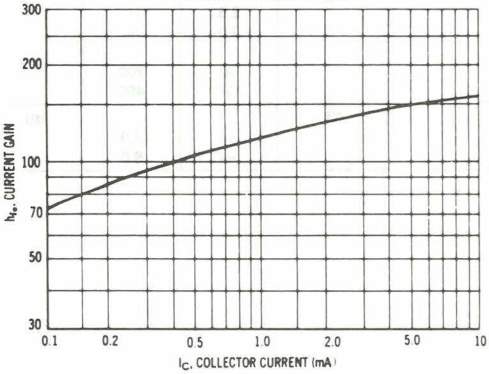


FIGURE 6 — OUTPUT ADMITTANCE

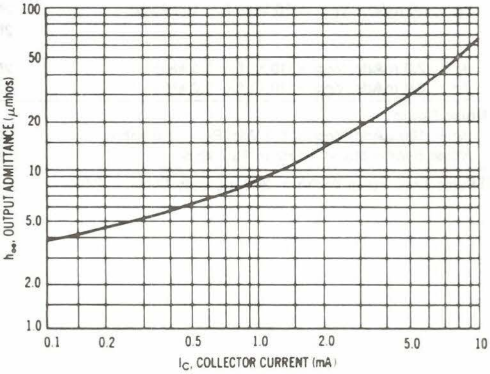


FIGURE 7 — INPUT IMPEDANCE

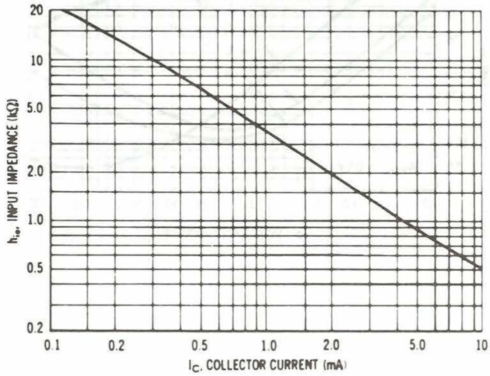
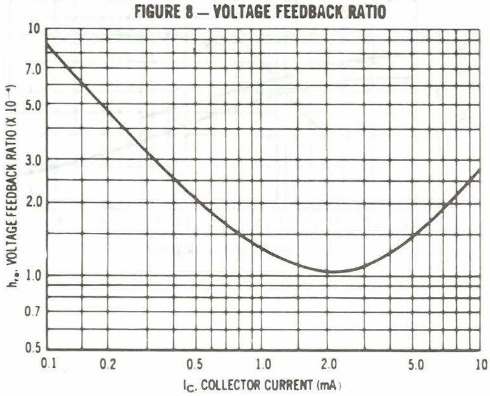


FIGURE 8 — VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 9 — DC CURRENT GAIN

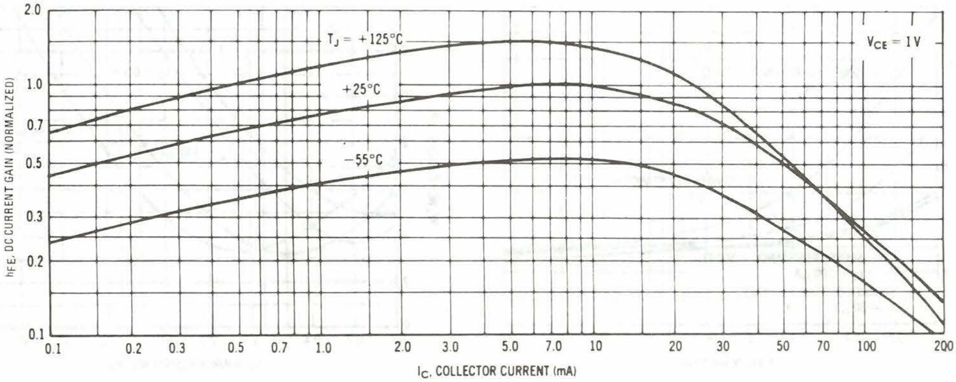


FIGURE 10 — COLLECTOR SATURATION REGION

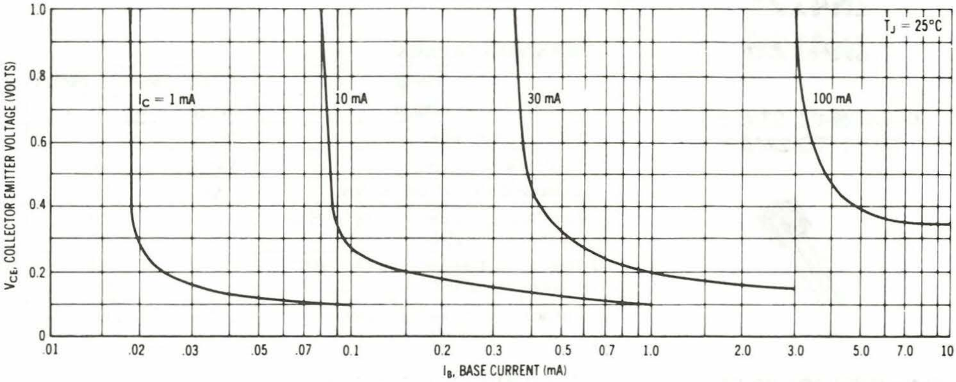


FIGURE 11 — "ON" VOLTAGES

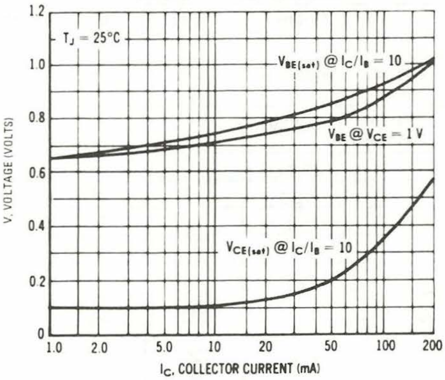
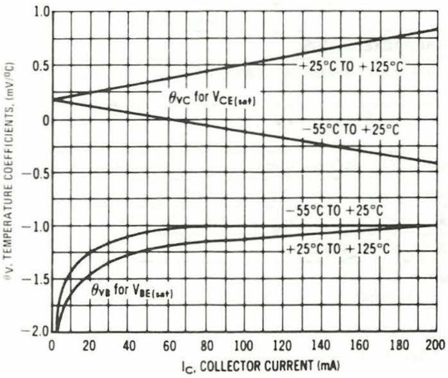


FIGURE 12 — TEMPERATURE COEFFICIENTS



2

2N4125
2N4126

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	2N4125	2N4126	Unit
Collector-Emitter Voltage	V_{CEO}	30	25	Vdc
Collector-Base Voltage	V_{CBO}	30	25	Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_E = 0$)	2N4125 2N4126	$V_{(BR)CEO}$	30 25	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	2N4125 2N4126	$V_{(BR)CBO}$	30 25	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)		I_{CBO}	—	50	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) ($I_C = 2.0$ mAdc, $V_{CE} = 1.0$ Vdc)	 2N4125 2N4126	h_{FE}	 50 120	 150 360	—
($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc)	2N4125 2N4126		25 60	— —	
Collector-Emitter Saturation Voltage(1) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{BE(sat)}$	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	 2N4125 2N4126	f_T	 200 250	 — —	MHz
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)		C_{ibo}	—	10	pF
Collector-Base Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{cb}	—	4.5	pF
Small-Signal Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	 2N4125 2N4126	h_{fe}	 50 120	 200 480	—
Current Gain — High Frequency ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	 2N4125 2N4126	$\|h_{fe}\|$	 2.0 2.5	 — —	—
Noise Figure ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc, $R_G = 1.0$ k ohm, Noise Bandwidth = 10 Hz to 15.7 kHz)	 2N4125 2N4126	NF	 — —	 5.0 4.0	dB

(1) Pulse Test: Pulse Width ≤ 300 μsec, Duty Cycle = 2.0%.

FIGURE 1 — CAPACITANCE

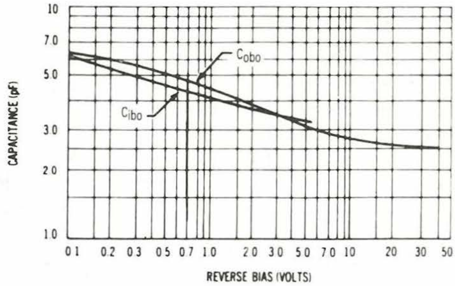
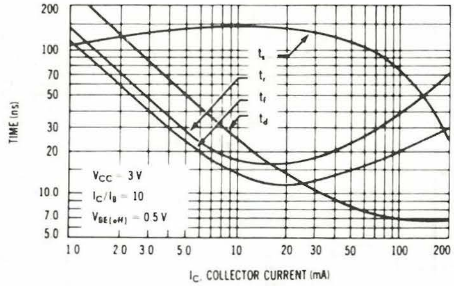


FIGURE 2 — SWITCHING TIMES



AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE

V_{CE} = 5.0 Vdc, T_A = 25°C,
Bandwidth = 1.0 Hz

FIGURE 3 — FREQUENCY VARIATIONS

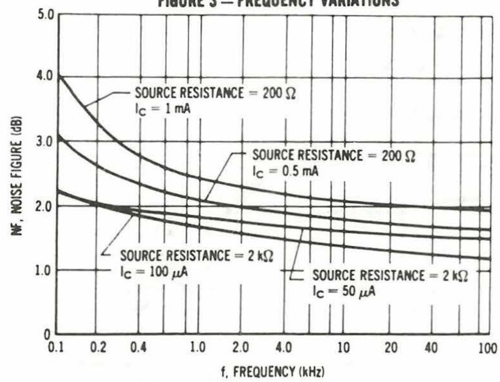
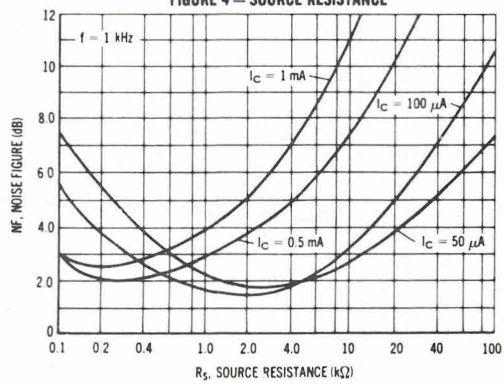


FIGURE 4 — SOURCE RESISTANCE



h PARAMETERS

V_{CE} = 10 V, f = 1 kHz, T_A = 25°C

FIGURE 5 — CURRENT GAIN

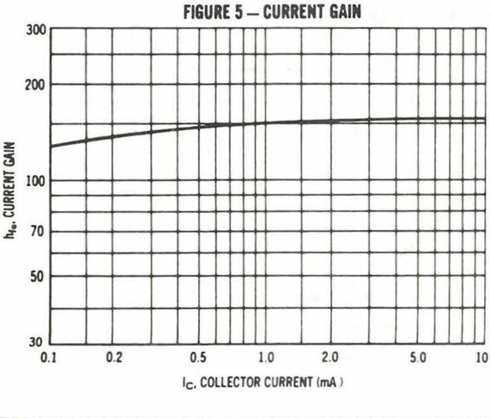


FIGURE 6 — OUTPUT ADMITTANCE

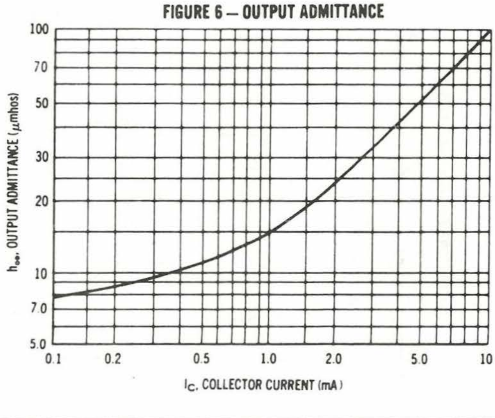


FIGURE 7 — INPUT IMPEDANCE

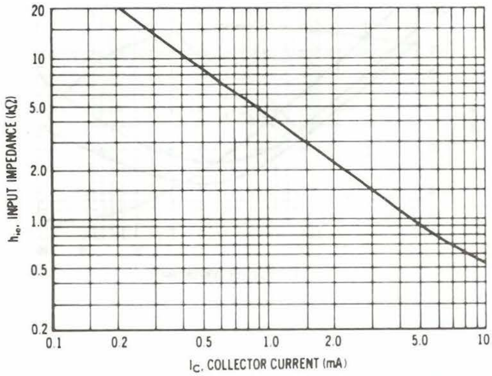
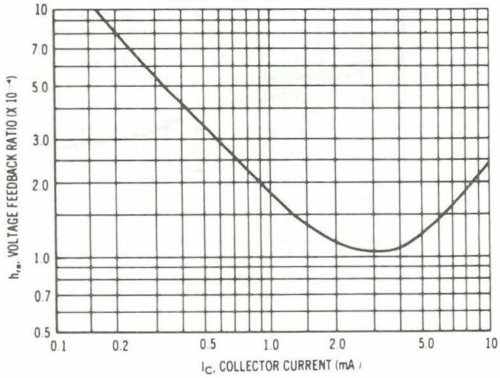


FIGURE 8 — VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 9 — DC CURRENT GAIN

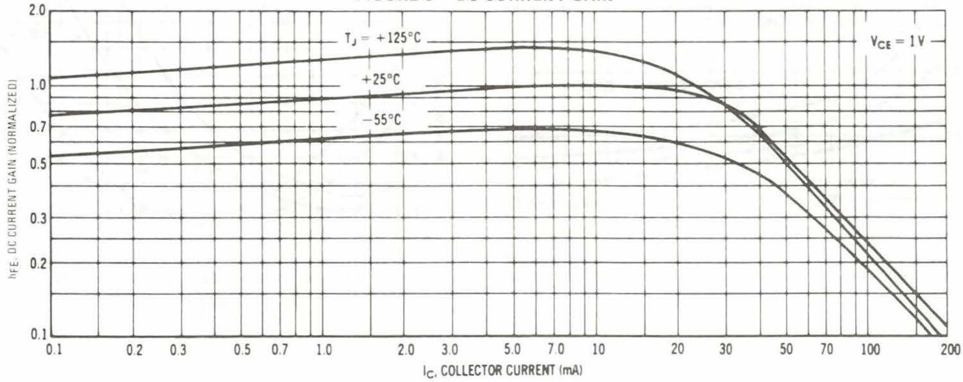


FIGURE 10 — COLLECTOR SATURATION REGION

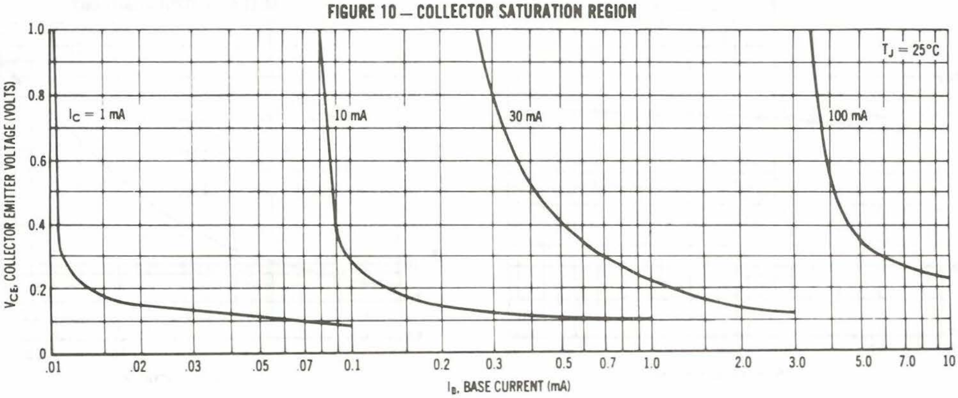


FIGURE 11 — "ON" VOLTAGES

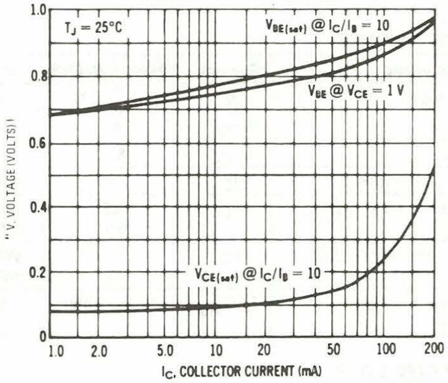
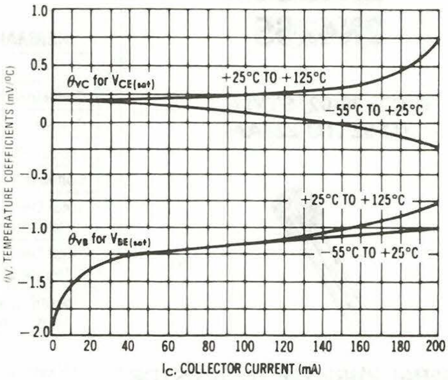


FIGURE 12 — TEMPERATURE COEFFICIENTS



2

2N4264
2N4265

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N4264	2N4265	Unit
Collector-Emitter Voltage	V_{CEO}	15	12	Vdc
Collector-Base Voltage	V_{CBO}	30		Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_E = 0$)	 2N4264 2N4265	$V_{(BR)CEO}$	 15 12	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)		$V_{(BR)CBO}$	20	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	6.0	—	Vdc
Base Cutoff Current ($V_{CE} = 12$ Vdc, $V_{EB(off)} = 0.25$ Vdc) ($V_{CE} = 12$ Vdc, $V_{EB(off)} = 0.25$ Vdc, $T_A = 100°C$)		I_{BEV}	 — —	 0.1 10	μAdc
Collector Cutoff Current ($V_{CE} = 12$ Vdc, $V_{EB(off)} = 0.25$ Vdc)		I_{CEX}	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc)	 2N4264 2N4265	h_{FE}	 25 30	 — —	—
($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)	2N4264 2N4265		40 100	160 400	
($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc, $T_A = -55°C$)	2N4264 2N4265		20 45	— —	
($I_C = 30$ mAdc, $V_{CE} = 1.0$ Vdc)	2N4264 2N4265		40 90	— —	
($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)(1)	2N4264 2N4265		30 55	— —	
($I_C = 200$ mAdc, $V_{CE} = 1.0$ Vdc)(1)	2N4264 2N4265		20 35	— —	
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 100$ mAdc, $I_B = 10$ mAdc)(1)		$V_{CE(sat)}$	 — —	 0.22 0.35	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 100$ mAdc, $I_B = 10$ mAdc)(1)		$V_{BE(sat)}$	 0.65 0.75	 0.80 0.95	Vdc

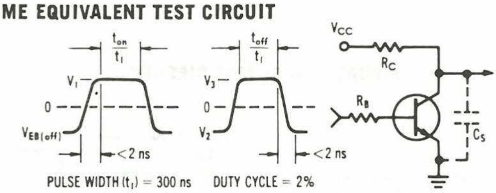
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	350	—	MHz
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	8.0	pF
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	—	4.0	pF
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 10 Vdc, $V_{EB(off)}$ = 2.0 Vdc, I_C = 100 mAdc, I_{B1} = 10 mAdc) (Fig. 1, Test Condition C)	t_d	—	8.0	ns
Rise Time		t_r	—	15	ns
Storage Time	V_{CC} = 10 Vdc, (I_C = 10 mAdc, for t_s) (I_C = 100 mA for t_f) I_{B1} = I_{B2} = 10 mAdc) (Fig. 1, Test Condition C)	t_s	—	20	ns
Fall Time		t_f	—	15	ns
Turn-On Time	(V_{CC} = 3.0 Vdc, $V_{EB(off)}$ = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc) (Fig. 1, Test Condition A)	t_{on}	—	25	ns
Turn-Off Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc) (Fig. 1, Test Condition A)	t_{off}	—	35	ns
Storage Time	(V_{CC} = 10 Vdc, I_C = 10 mA I_{B1} = I_{B2} = 10 mAdc) (Fig. 1, Test Condition A)	t_s	—	20	ns
Total Control Charge	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_B = mAdc) (Fig. 1, Test Condition B)	Q_T	—	80	pC

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

FIGURE 1 — SWITCHING TIME EQUIVALENT TEST CIRCUIT

TEST CONDITION	I_C	V_{CC}	R_B	R_C	$C_{S(max)}$	$V_{EB(off)}$	V_1	V_2	V_3
	mA	V	Ω	Ω	pF	V	V	V	V
A	10	3	3300	270	4	−1.5	10.55	−4.15	10.70
B	10	10	560	960	4	—	—	−4.65	6.55
C	100	10	560	96	12	−2.0	6.35	−4.65	6.55



CURRENT GAIN CHARACTERISTICS

FIGURE 2 — MINIMUM CURRENT GAIN

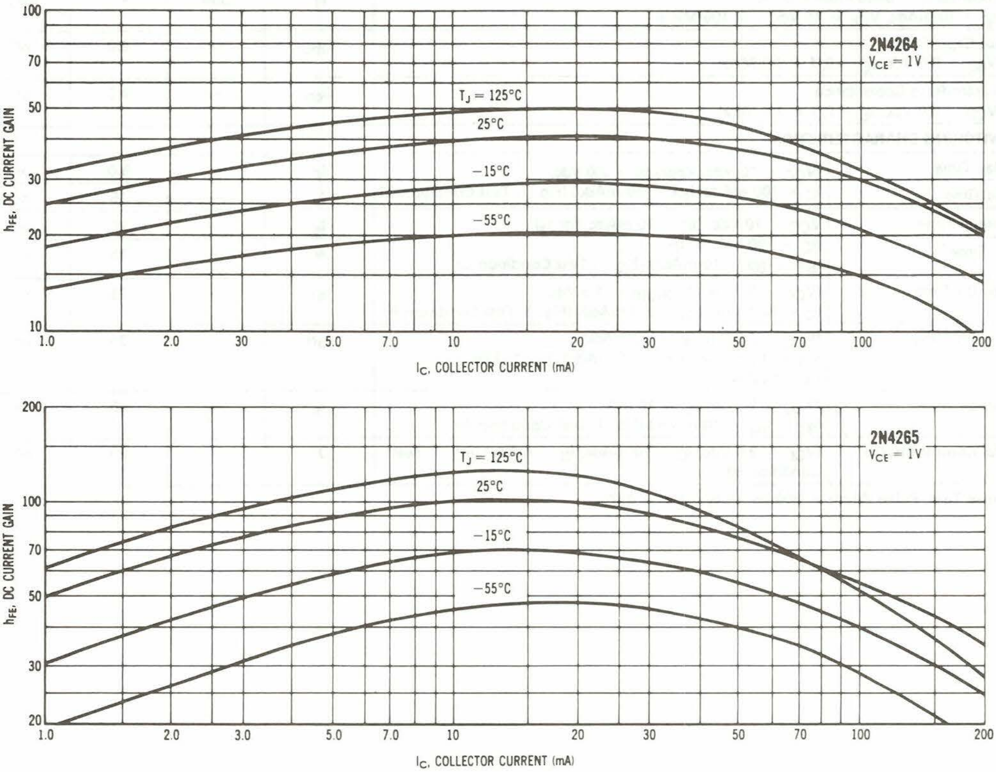


FIGURE 3 — Q_T TEST CIRCUIT

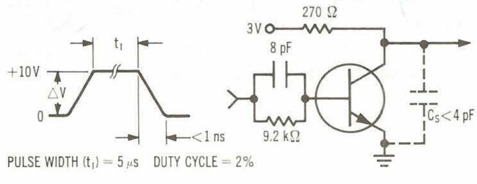
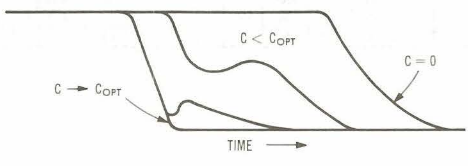


FIGURE 4 — TURN-OFF WAVEFORM



NOTE 1

When a transistor is held in a conductive state by a base current, I_B, a charge, Q_S, is developed or "stored" in the transistor. Q_S may be written: $Q_S = Q_1 + Q_V + Q_X$.

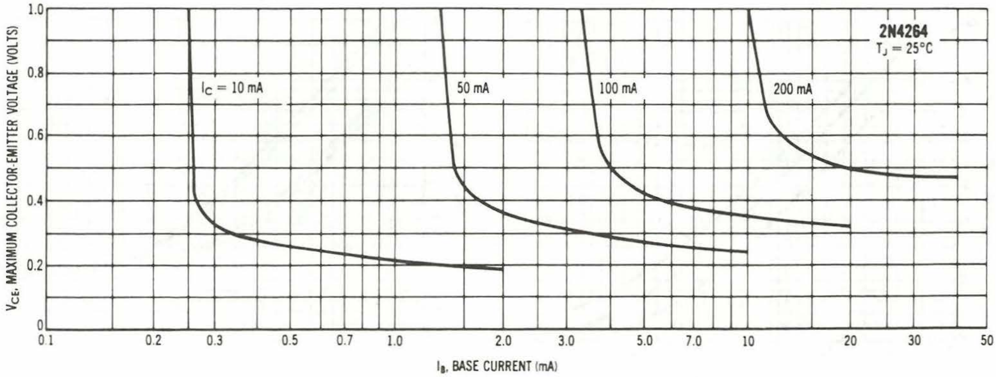
Q_1 is the charge required to develop the required collector current. This charge is primarily a function of alpha cutoff frequency. Q_V is the charge required to charge the collector-base feedback capacity. Q_X is excess charge resulting from overdrive, i.e., operation in saturation.

The charge required to turn a transistor "on" to the edge of saturation is the sum of Q_1 and Q_V which is defined as the active region charge, Q_A. $Q_A = I_{B1}t_r$ when the transistor is driven by a constant current step (I_{B1}) and $I_{B1} << \frac{I_C}{h_{FE}}$.

If I_B were suddenly removed, the transistor would continue to conduct until Q_S is removed from the active regions through an external path or through internal recombination. Since the internal recombination time is long compared to the ultimate capability of a transistor, a charge, Q_T, of opposite polarity, equal in magnitude, can be stored on an external capacitor, C, to neutralize the internal charge and considerably reduce the turn-off time of the transistor. Figure 3 shows the test circuit and Figure 4 the turn-off waveform. Given Q_T from Figure 13, the external C for worst-case turn-off in any circuit is: $C = Q_T/\triangle V$, where $\triangle V$ is defined in Figure 3.

"ON" CONDITION CHARACTERISTICS

FIGURE 5 — COLLECTOR SATURATION REGION



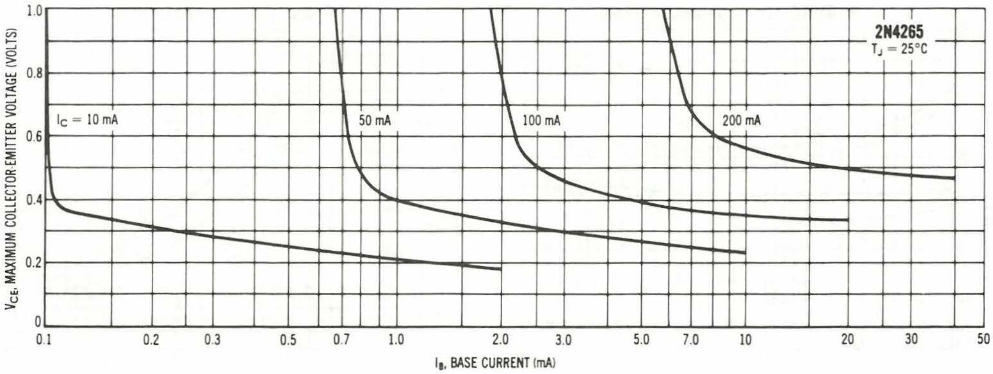


FIGURE 6 — SATURATION VOLTAGE LIMITS

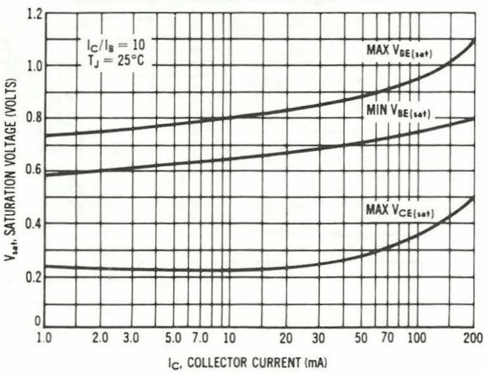
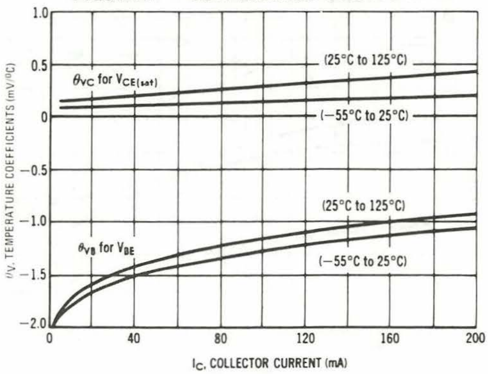


FIGURE 7 — TEMPERATURE COEFFICIENTS



DYNAMIC CHARACTERISTICS

FIGURE 8 — DELAY TIME

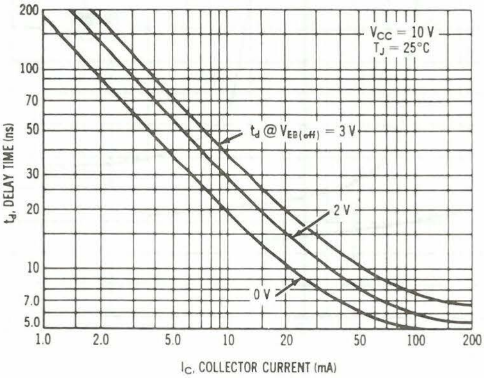


FIGURE 9 — RISE TIME

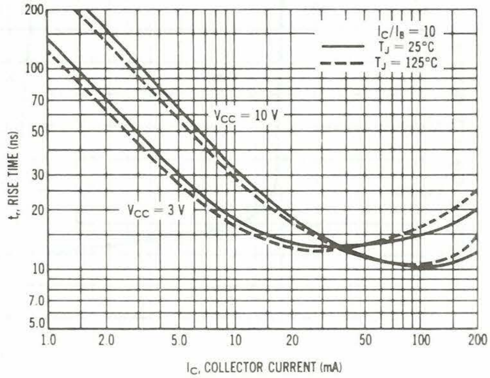


FIGURE 10 — STORAGE TIME

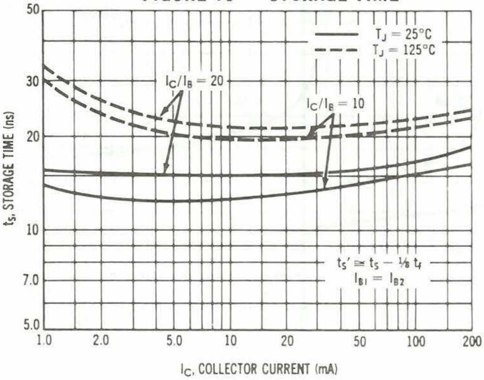


FIGURE 11 — FALL TIME

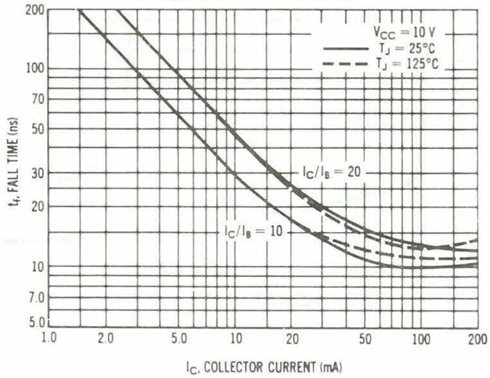


FIGURE 12 — JUNCTION CAPACITANCE

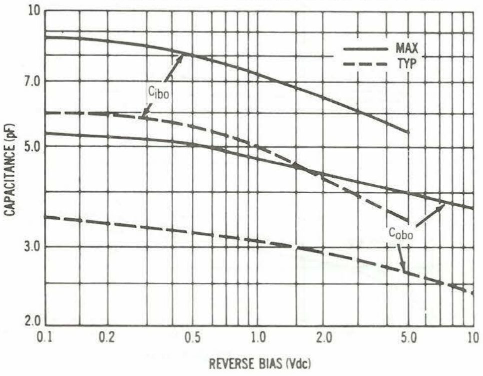
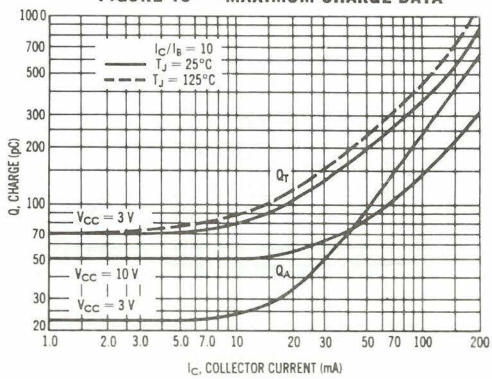


FIGURE 13 — MAXIMUM CHARGE DATA



2N4400
2N4401

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	600	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)		$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)		$V_{(BR)EBO}$	6.0	—	Vdc
Base Cutoff Current ($V_{CE} = 35$ Vdc, $V_{EB} = 0.4$ Vdc)		I_{BEV}	—	0.1	μAdc
Collector Cutoff Current ($V_{CE} = 35$ Vdc, $V_{EB} = 0.4$ Vdc)		I_{CEX}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain		h_{FE}			—
($I_C = 0.1$ mAdc, $V_{CE} = 1.0$ Vdc)	2N4401		20	—	
($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc)	2N4400 2N4401		20 40	— —	
($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)	2N4400 2N4401		40 80	— —	
($I_C = 150$ mAdc, $V_{CE} = 1.0$ Vdc)	2N4400 2N4401		50 100	150 300	
($I_C = 500$ mAdc, $V_{CE} = 2.0$ Vdc)	2N4400 2N4401		20 40	— —	
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)		$V_{CE(sat)}$	 — —	 0.4 0.75	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)		$V_{BE(sat)}$	 0.75 —	 0.95 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 20$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	 2N4400 2N4401	f_T	 200 250	 — —	MHz
Collector-Base Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 100 kHz)		C_{cb}	—	6.5	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{eb}	—	30	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N4400 2N4401	h_{ie}	0.5 1.0	7.5 15	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{re}	0.1	8.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N4400 2N4401	h_{fe}	20 40	250 500	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	1.0	30	μmhos
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 30 Vdc, V_{EB} = 2.0 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_d	—	15	ns
Rise Time		t_r	—	20	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_s	—	225	ns
Fall Time		t_f	—	30	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 — TURN-ON TIME

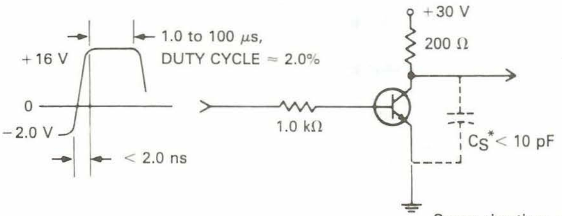
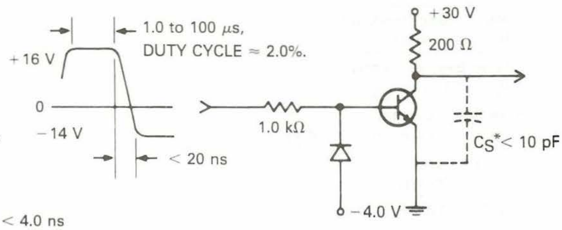


FIGURE 2 — TURN-OFF TIME



Scope rise time < 4.0 ns
*Total shunt capacitance of test jig connectors, and oscilloscope

TRANSIENT CHARACTERISTICS

——— 25°C – – – 100°C

FIGURE 3 — CAPACITANCES

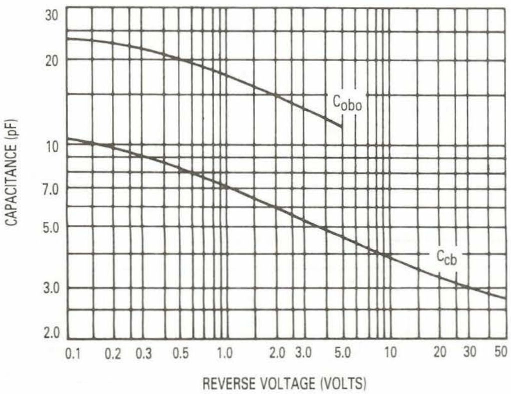


FIGURE 4 — CHARGE DATA

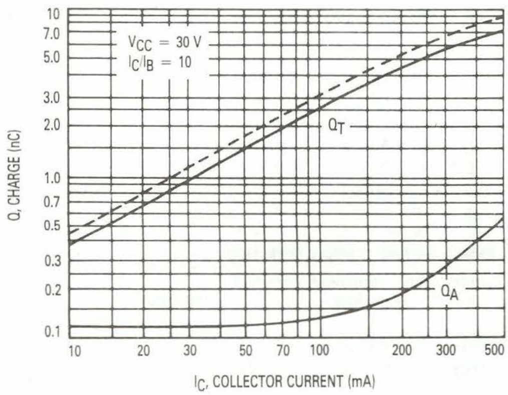


FIGURE 5 — TURN-ON TIME

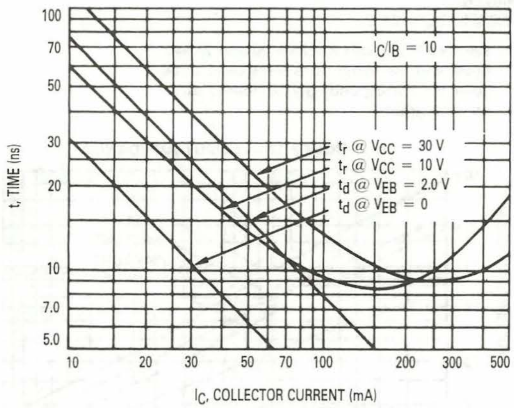


FIGURE 6 — RISE AND FALL TIMES

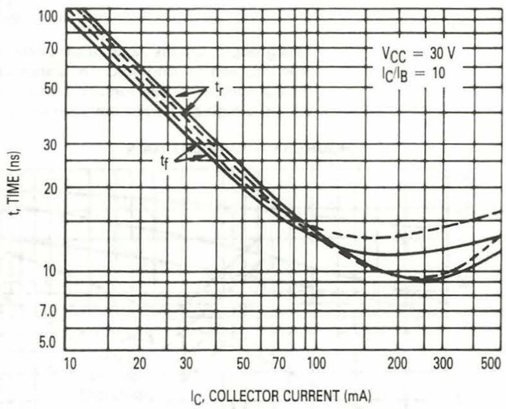


FIGURE 7 — STORAGE TIME

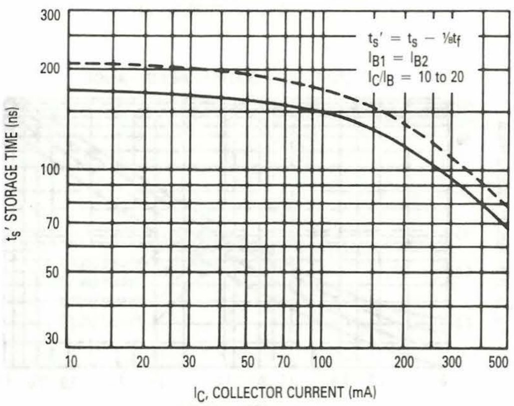
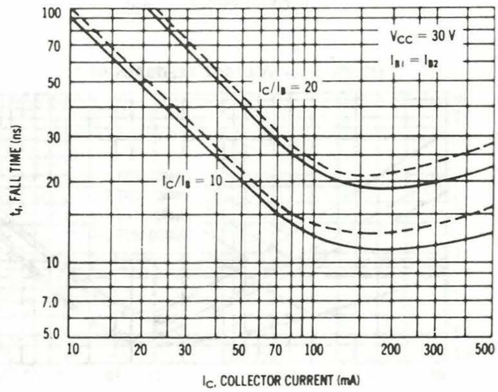


FIGURE 8 — FALL TIME



SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

V_{CE} = 10 Vdc, T_A = 25°C
Bandwidth = 1.0 Hz

FIGURE 9 — FREQUENCY EFFECTS

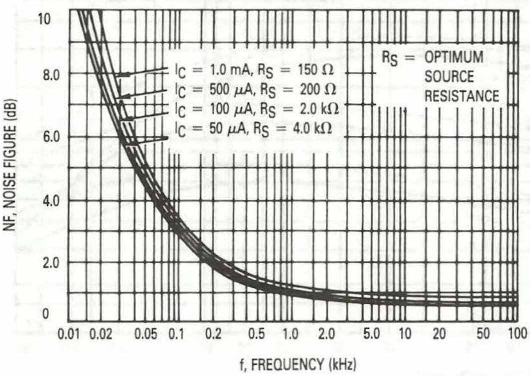
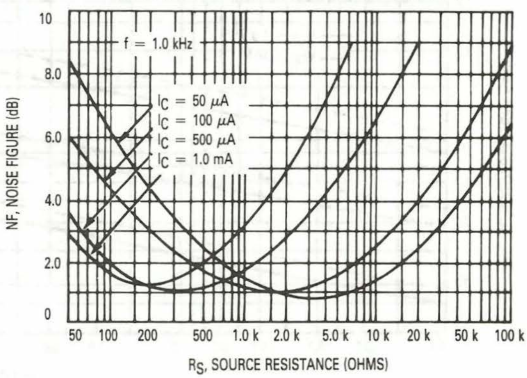


FIGURE 10 — SOURCE RESISTANCE EFFECTS



h PARAMETERS
V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C

This group of graphs illustrates the relationship between h_{fe} and other "h" parameters for this series of transistors. To obtain these curves, a high-gain and a low-gain unit were selected from both the 2N4400 and 2N4401 lines, and the same units were used to develop the correspondingly numbered curves on each graph.

FIGURE 11 — CURRENT GAIN

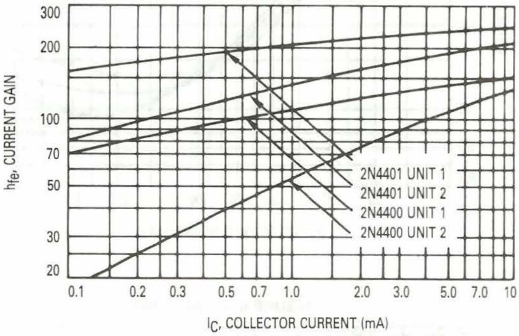


FIGURE 12 — UNPUT IMPEDANCE

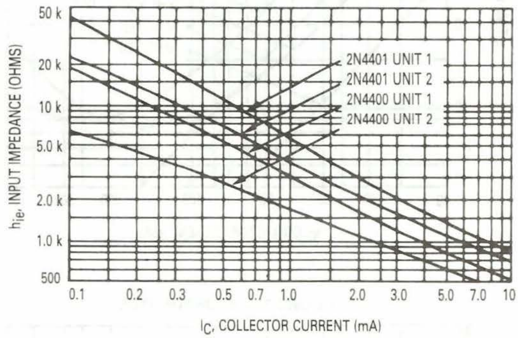


FIGURE 13 — VOLTAGE FEEDBACK RATIO

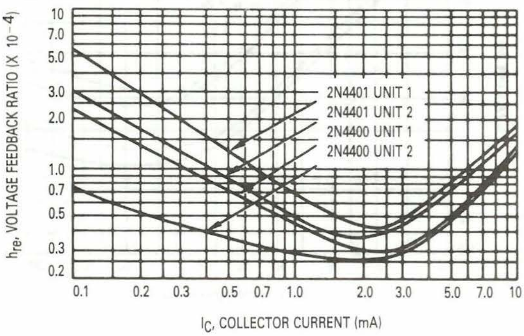
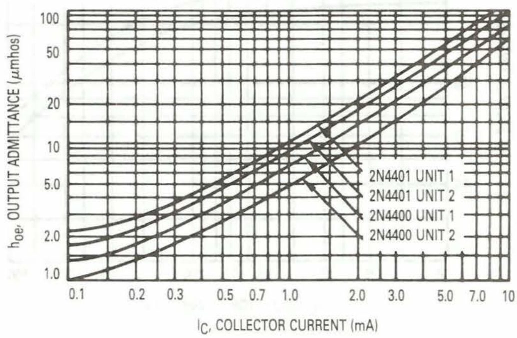


FIGURE 14 — OUTPUT ADMITTANCE



STATIC CHARACTERISTICS

FIGURE 15 — DC CURRENT GAIN

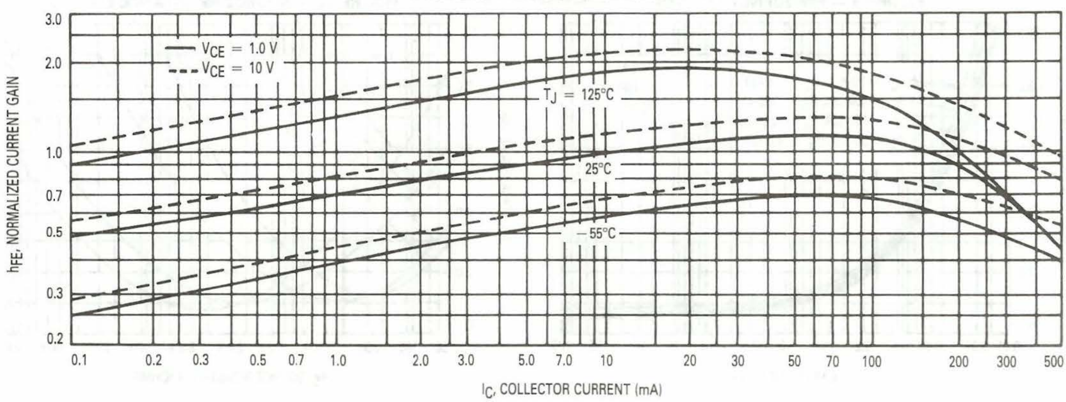


FIGURE 16 — COLLECTOR SATURATION REGION

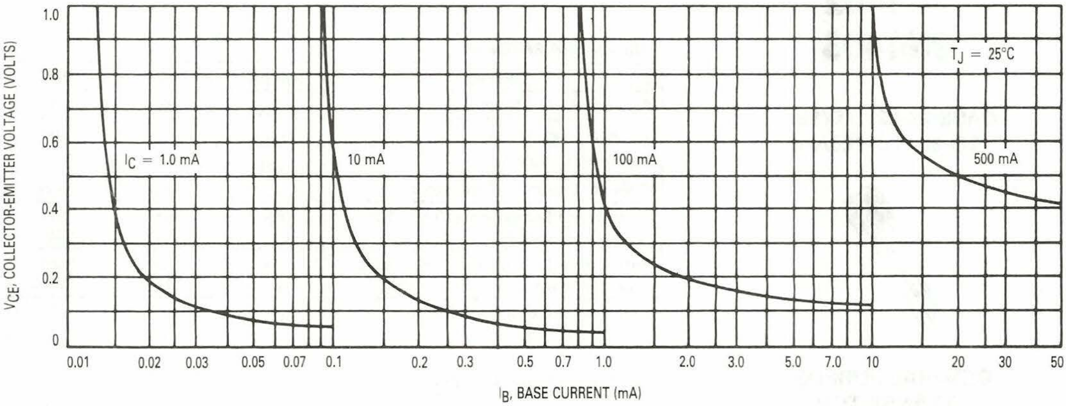


FIGURE 17 — "ON" VOLTAGES

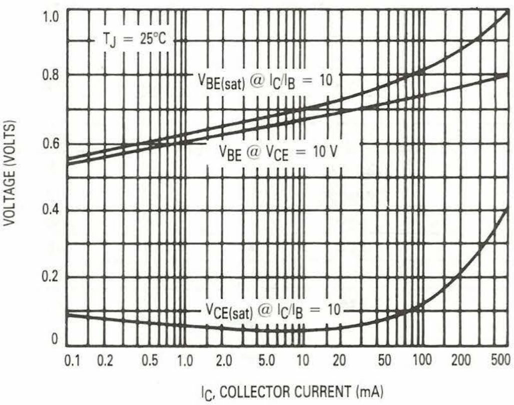
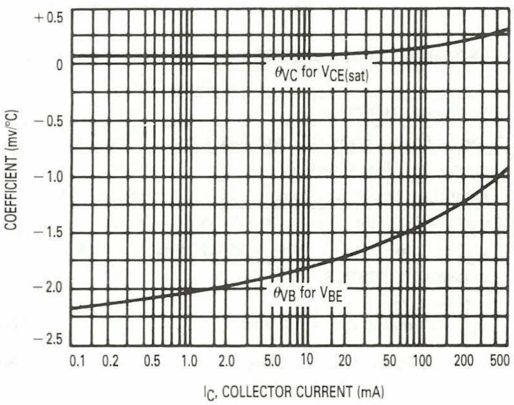


FIGURE 18 — TEMPERATURE COEFFICIENTS



2

2N4402
2N4403

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	600	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)		$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Base Cutoff Current ($V_{CE} = 35$ Vdc, $V_{BE} = 0.4$ Vdc)		I_{BEV}	—	0.1	μAdc
Collector Cutoff Current ($V_{CE} = 35$ Vdc, $V_{BE} = 0.4$ Vdc)		I_{CEX}	—	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
($I_C = 0.1$ mAdc, $V_{CE} = 1.0$ Vdc)	2N4403		30	—	
($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc)	2N4402 2N4403		30 60	— —	
($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)	2N4402 2N4403		50 100	— —	
($I_C = 150$ mAdc, $V_{CE} = 2.0$ Vdc)(1)	2N4402 2N4403		50 100	150 300	
($I_C = 500$ mAdc, $V_{CE} = 2.0$ Vdc)(1)	Both		20	—	
Collector-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)		$V_{CE(sat)}$	 — —	 0.4 0.75	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)		$V_{BE(sat)}$	 0.75 —	 0.95 1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 20$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	 2N4402 2N4403	f_T	 150 200	 — —	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 140 kHz)		C_{cb}	—	8.5	pF
Emitter-Base Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 140 kHz)		C_{eb}	—	30	pF
Input Impedance ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	 2N4402 2N4403	h_{ie}	 750 1.5k	 7.5k 15k	ohms

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{re}	0.1	8.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N4402	h_{fe}	30	250	—
	2N4403		60	500	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	1.0	100	μmhos

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
Delay Time	(V_{CC} = 30 Vdc, V_{BE} = 2.0 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_d	—	15	ns
Rise Time		t_r	—	20	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_s	—	225	ns
Fall Time		t_f	—	30	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

SWITCHING TIME EQUIVALENT TEST CIRCUIT

FIGURE 1 — TURN ON TIME

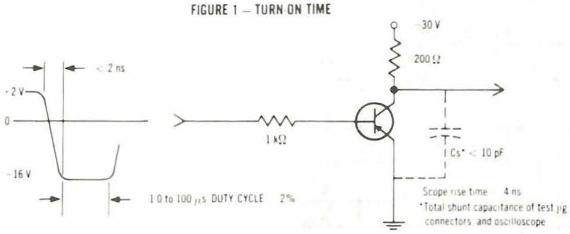
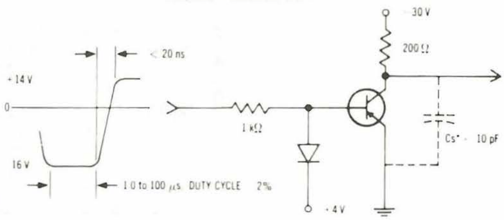


FIGURE 2 — TURN OFF TIME



TRANSIENT CHARACTERISTICS

—— 25°C – – – 100°C

FIGURE 3 — CAPACITANCES

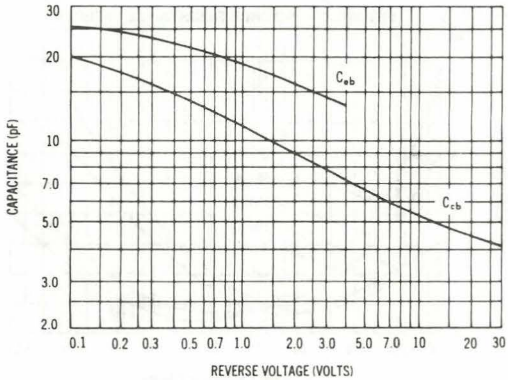
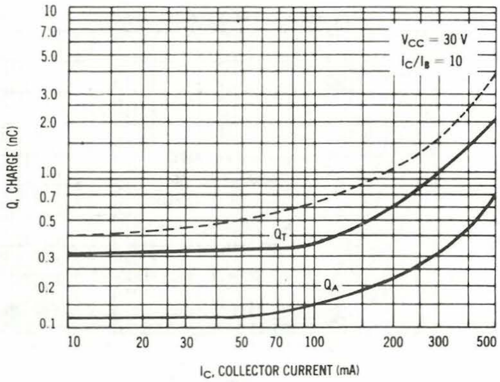


FIGURE 4 — CHARGE DATA



2

FIGURE 5 — TURN-ON TIME

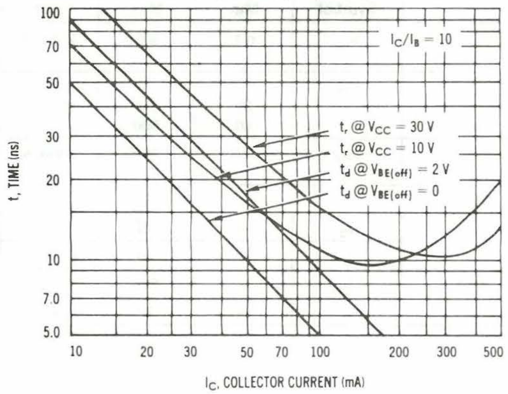


FIGURE 6 — RISE TIME

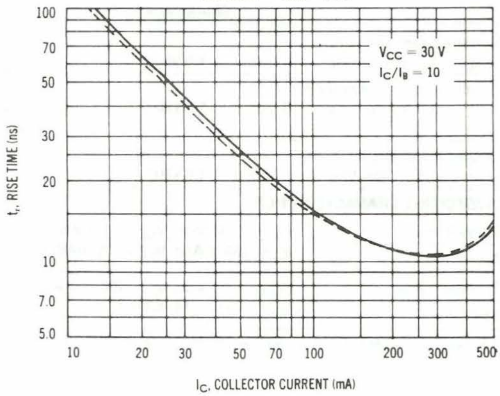
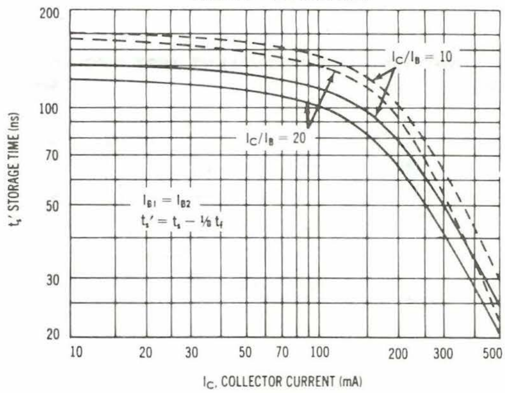


FIGURE 7 — STORAGE TIME



SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

$V_{CE} = 10$ Vdc, $T_A = 25^\circ C$
Bandwidth = 1.0 Hz

FIGURE 8 — FREQUENCY EFFECTS

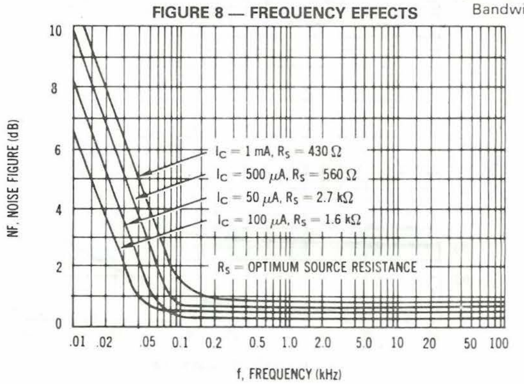
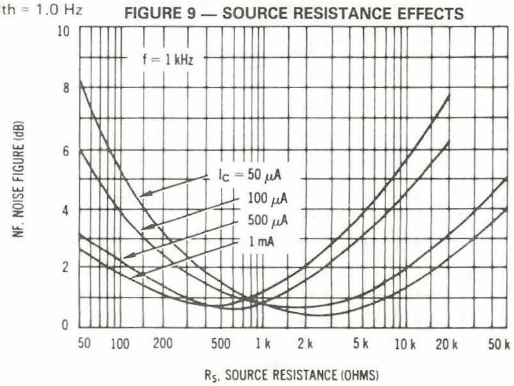


FIGURE 9 — SOURCE RESISTANCE EFFECTS



h PARAMETERS

$V_{CE} = 10$ Vdc, f = 1 kHz, $T_A = 25°C$

This group of graphs illustrates the relationship between h_{fe} and other "h" parameters for this series of transistors. To obtain these curves, a high-gain and a low-gain unit were selected from both the 2N4402 and 2N4403 lines, and the same units were used to develop the correspondingly-numbered curves on each graph.

FIGURE 10 — CURRENT GAIN

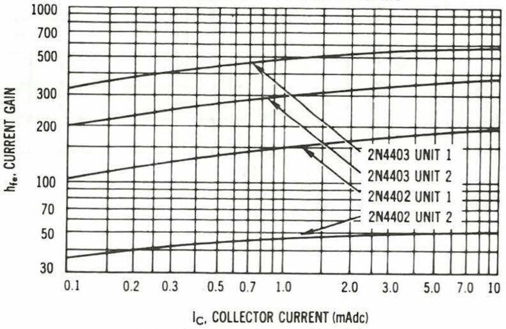


FIGURE 11 — INPUT IMPEDANCE

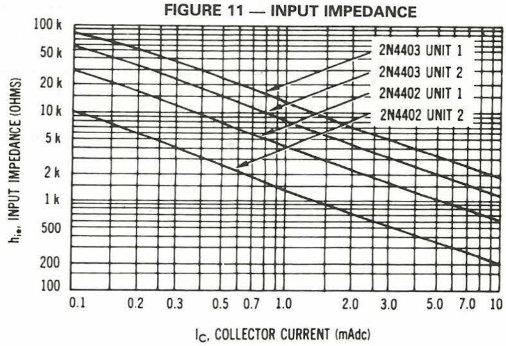


FIGURE 12 — VOLTAGE FEEDBACK RATIO

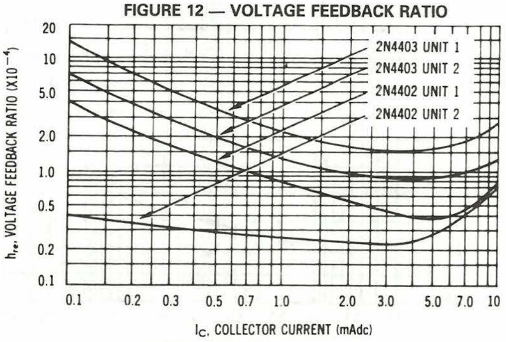
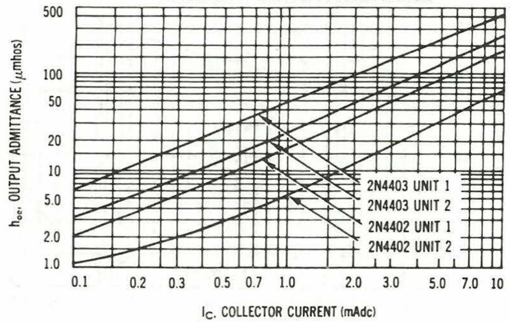


FIGURE 13 — OUTPUT ADMITTANCE



STATIC CHARACTERISTICS

FIGURE 14 — DC CURRENT GAIN

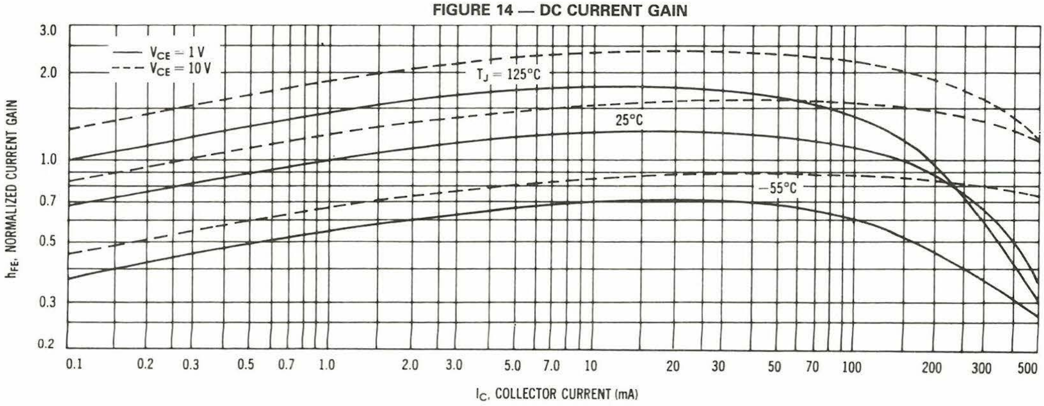


FIGURE 15 — COLLECTOR SATURATION REGION

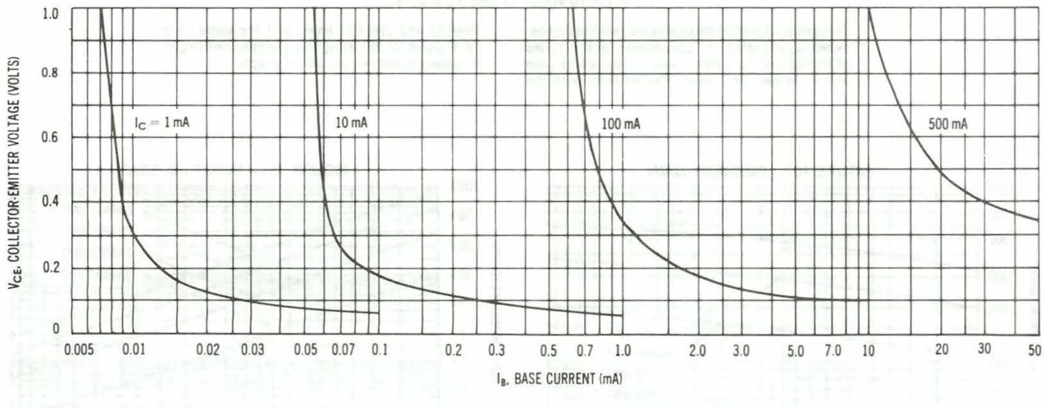


FIGURE 16 — "ON" VOLTAGES

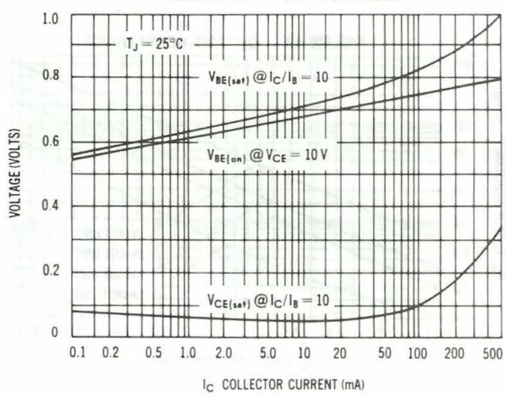
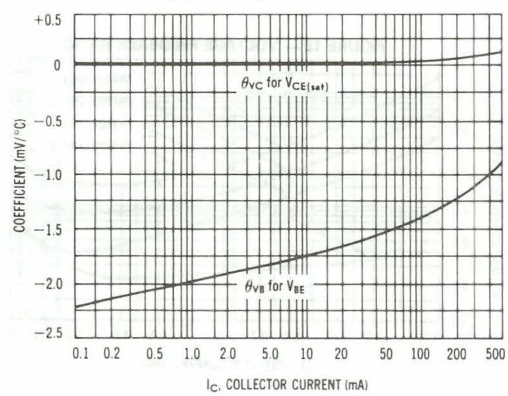


FIGURE 17 — TEMPERATURE COEFFICIENTS



2N4409
2N4410

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N5550 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N4409	2N4410	Unit
Collector-Emitter Voltage	V_{CEO}	50	80	Vdc
Collector-Base Voltage	V_{CBO}	80	120	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	250		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

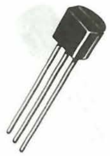
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	 2N4409 2N4410	$V_{(BR)CEO}$	50 80	 — —	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 500$ μAdc, $V_{BE} = 5.0$ Vdc, $R_{BE} = 8.2$ kohms)	 2N4409 2N4410	$V_{(BR)CEX}$	 80 120	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	 2N4409 2N4410	$V_{(BR)CBO}$	 80 120	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 60$ Vdc, $I_E = 0$, $T_A = 100°C$) ($V_{CB} = 100$ Vdc, $I_E = 0$) ($V_{CB} = 100$ Vdc, $I_E = 0$, $T_A = 100°C$)	 2N4409 2N4409 2N4410 2N4410	I_{CBO}	 — — — —	 0.01 1.0 0.01 1.0	μAdc
Emitter Cutoff Current ($V_{BE} = 4.0$ Vdc, $I_C = 0$)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)		h_{FE}	60 60	— 400	—
Collector-Emitter Saturation Voltage ($I_C = 1.0$ mAdc, $I_B = 0.1$ mAdc)		$V_{CE(sat)}$	—	0.2	Vdc
Base-Emitter Saturation Voltage ($I_C = 1.0$ mAdc, $I_B = 0.1$ mAdc)		$V_{BE(sat)}$	—	0.8	Vdc
Base-Emitter On Voltage ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)		$V_{BE(on)}$	—	0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 30 MHz)		f_T	60	300	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 140 kHz, emitter guarded)		C_{cb}	—	12	pF
Emitter-Base Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 140 kHz, collector guarded)		C_{eb}	—	50	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$.

2N5086
2N5087

CASE 29-02, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CBO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 1.0$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	50	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)		$V_{(BR)CBO}$	50	—	Vdc
Collector Cutoff Current ($V_{CB} = 10$ Vdc, $I_E = 0$) ($V_{CB} = 35$ Vdc, $I_E = 0$)		I_{CBO}	 — —	 10 50	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc)	 2N5086 2N5087	h_{FE}	 150 250	 500 800	—
($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)	2N5086 2N5087		150 250	— —	
($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)(2)	2N5086 2N5087		150 250	— —	
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)		$V_{CE(sat)}$	—	0.3	Vdc
Base-Emitter On Voltage ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)		$V_{BE(on)}$	—	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 500$ μAdc, $V_{CE} = 5.0$ Vdc, f = 20 MHz)		f_T	40	—	MHz
Collector-Base Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 100 kHz)		C_{cb}	—	4.0	pF
Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz)	 2N5086 2N5087	h_{fe}	 150 250	 600 900	—
Noise Figure ($I_C = 20$ μAdc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ k ohms, f = 10 Hz to 15.7 kHz)	 2N5086 2N5087	NF	 — —	 3.0 2.0	dB
($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc, $R_S = 3.0$ k ohms, f = 1.0 kHz)	2N5086 2N5087		— —	3.0 2.0	

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

TYPICAL NOISE CHARACTERISTICS
(V_{CE} = 5.0 Vdc, T_A = 25°C)

FIGURE 1 — NOISE VOLTAGE

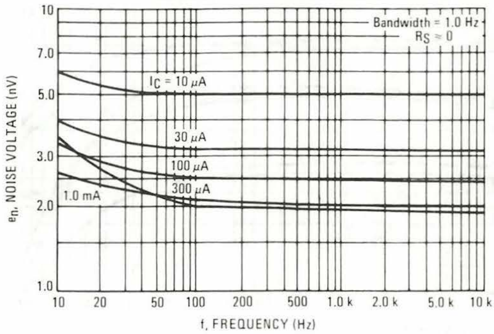
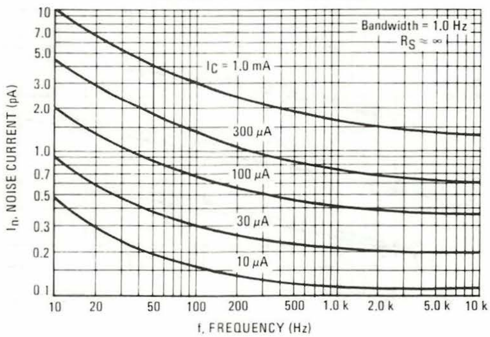


FIGURE 2 — NOISE CURRENT



NOISE FIGURE CONTOURS
(V_{CE} = 5.0 Vdc, T_A = 25°C)

FIGURE 3 — NARROW BAND, 100 Hz

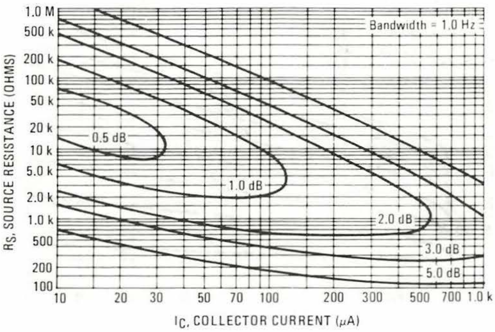


FIGURE 4 — NARROW BAND, 1.0 KHz

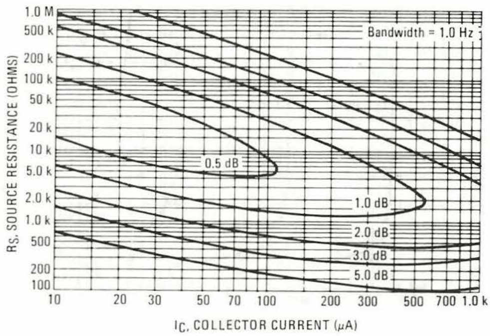
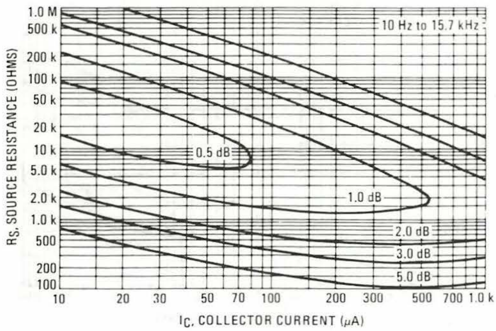


FIGURE 5 — WIDEBAND



Noise Figure is Defined as:

$$NF = 20 \log_{10} \left[\frac{e_n^2 + 4KTR_S + I_n^2 R_S^2}{4KTR_S} \right]^{1/2}$$

e_n = Noise Voltage of the Transistor referred to the input. (Figure 3)
I_n = Noise Current of the transistor referred to the input (Figure 4)
K = Boltzman's Constant (1.38×10^{-23} j/°K)
T = Temperature of the Source Resistance (°K)
R_S = Source Resistance (Ohms)

TYPICAL STATIC CHARACTERISTICS

FIGURE 6 — DC CURRENT GAIN

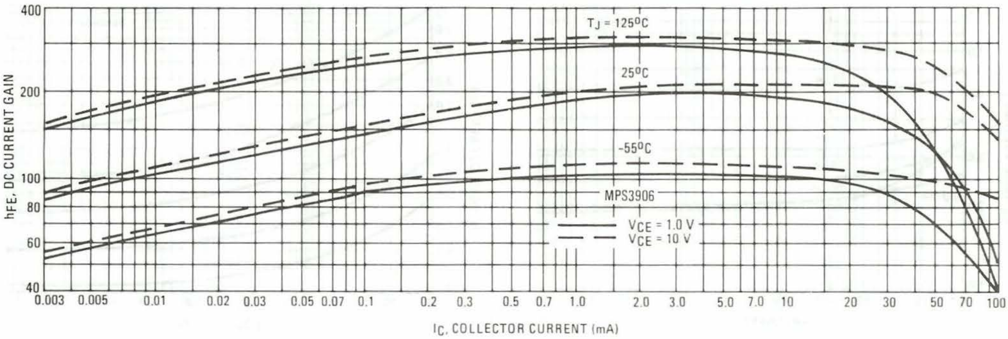


FIGURE 7 — COLLECTOR SATURATION REGION

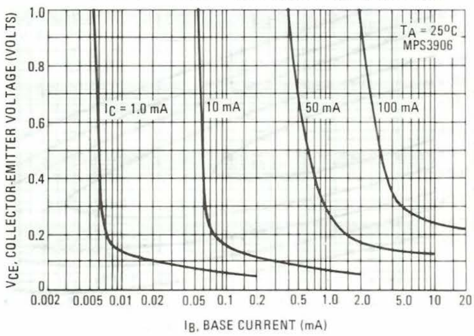


FIGURE 8 — COLLECTOR CHARACTERISTICS

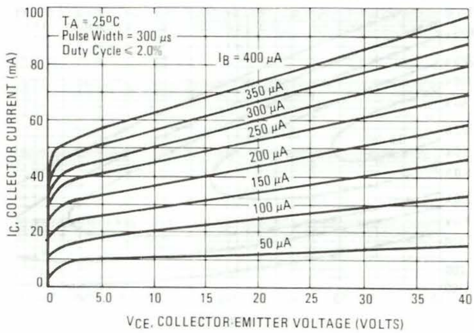


FIGURE 9 — "ON" VOLTAGES

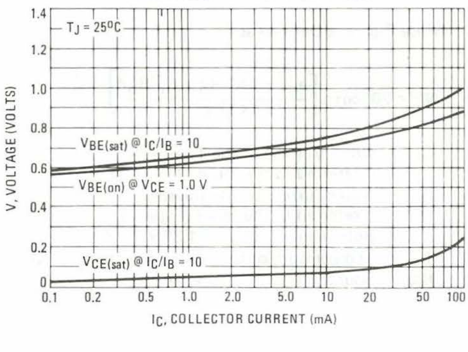
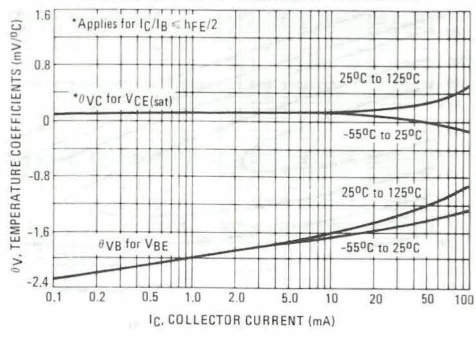


FIGURE 10 — TEMPERATURE COEFFICIENTS



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 11 — TURN-ON TIME

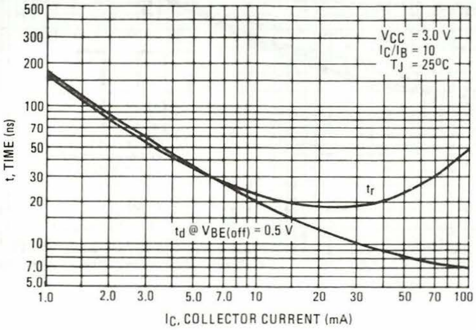


FIGURE 12 — TURN-OFF TIME

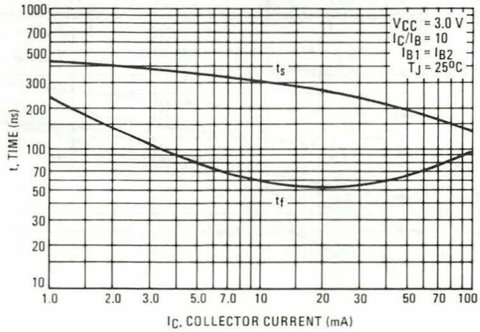


FIGURE 13 — CURRENT-GAIN — BANDWIDTH PRODUCT

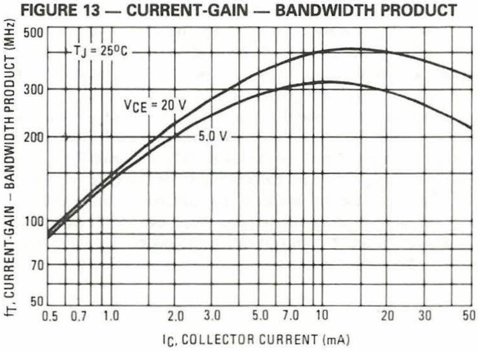


FIGURE 14 — CAPACITANCE

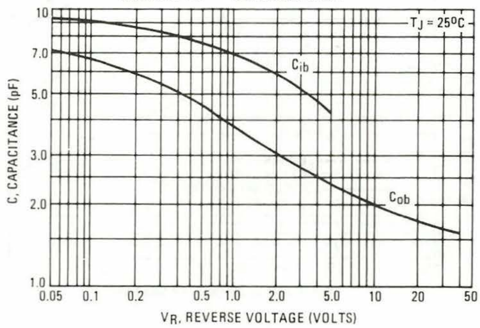


FIGURE 15 — INPUT IMPEDANCE

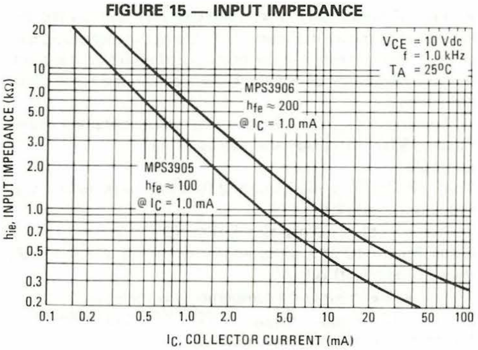
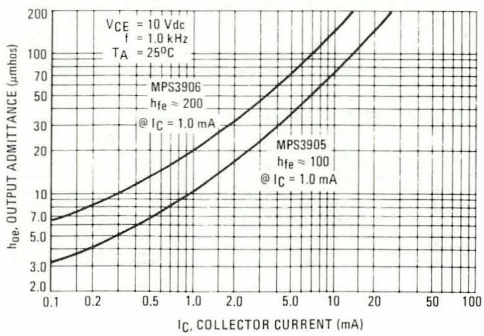


FIGURE 16 — OUTPUT ADMITTANCE



2

FIGURE 17 — THERMAL RESPONSE

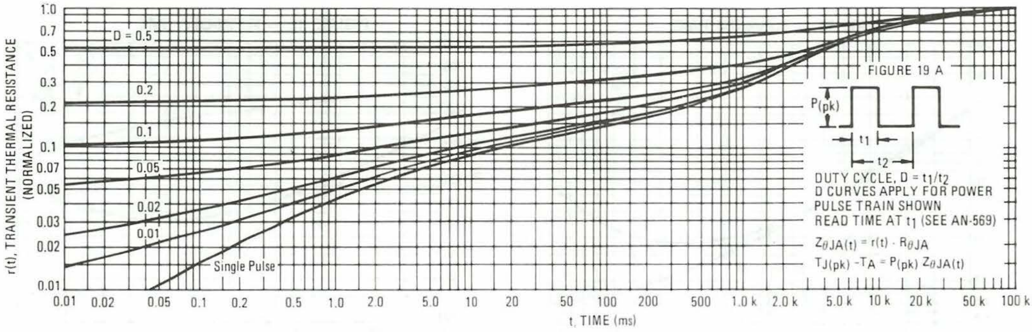
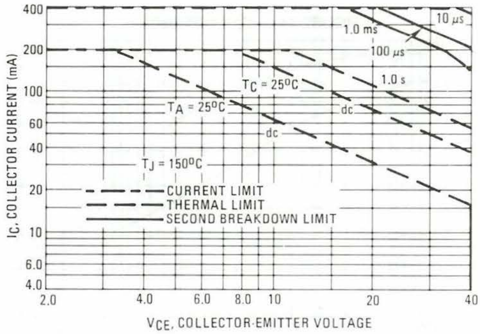


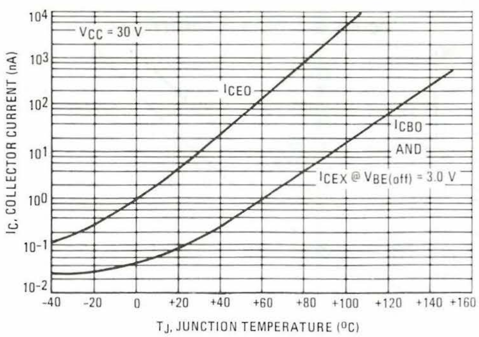
FIGURE 18 — ACTIVE-REGION SAFE OPERATING AREA



The safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 20 is based upon $T_{J(pk)} = 150^oC$; T_C or T_A is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 19. At high case or ambient temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415A).

FIGURE 19 — TYPICAL COLLECTOR LEAKAGE CURRENT



DESIGN NOTE: USE OF THERMAL RESPONSE DATA

A train of periodical power pulses can be represented by the model as shown in Figure 19A. Using the model and the device thermal response the normalized effective transient thermal resistance of Figure 19 was calculated for various duty cycles.

To find $Z_{\theta JA(t)}$, multiply the value obtained from Figure 19 by the steady state value $R_{\theta JA}$.

Example:

The MPS3905 is dissipating 2.0 watts peak under the following conditions:

t1 = 1.0 ms, t2 = 5.0 ms (D = 0.2)

Using Figure 19 at a pulse width of 1.0 ms and D = 0.2, the reading of r(t) is 0.22.

The peak rise in junction temperature is therefore

$\Delta T = r(t) \times P_{(pk)} \times R_{\theta JA} = 0.22 \times 2.0 \times 200 = 88^oC$.

For more information, see AN-569.

2N5088
2N5089

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MPSA18 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N5088	2N5089	Unit
Collector-Emitter Voltage	V_{CEO}	30	25	Vdc
Collector-Base Voltage	V_{CBO}	35	30	Vdc
Emitter-Base Voltage	V_{EBO}	4.5		Vdc
Collector Current — Continuous	I_C	50		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 1.0$ mAdc, $I_B = 0$)	2N5088 2N5089	$V_{(BR)CEO}$	30 25	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	2N5088 2N5089	$V_{(BR)CBO}$	35 30	— —	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$) ($V_{CB} = 15$ Vdc, $I_E = 0$)	2N5088 2N5089	I_{CBO}	— —	50 50	nAdc
Emitter Cutoff Current ($V_{EB(off)} = 3.0$ Vdc, $I_C = 0$) ($V_{EB(off)} = 4.5$ Vdc, $I_C = 0$)		I_{EBO}	— —	50 100	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc)	 2N5088 2N5089	h_{FE}	 300 400	 900 1200	—
($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)	2N5088 2N5089		350 450	— —	
($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)(2)	2N5088 2N5089		300 400	— —	
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)(2)		$V_{BE(on)}$	—	0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 500$ μAdc, $V_{CE} = 5.0$ Vdc, f = 20 MHz)		f_T	50	—	MHz
Collector-Base Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 100 kHz)		C_{cb}	—	4.0	pF
Emitter-Base Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)		C_{eb}	—	10	pF
Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz)	 2N5088 2N5089	h_{fe}	 350 450	 1400 1800	—
Noise Figure ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ kohms, f = 10 Hz to 15.7 kHz)	 2N5088 2N5089	NF	 — —	 3.0 2.0	dB

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

2N5208

CASE 29-02, STYLE 2
TO-92 (TO-226AA)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	65 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

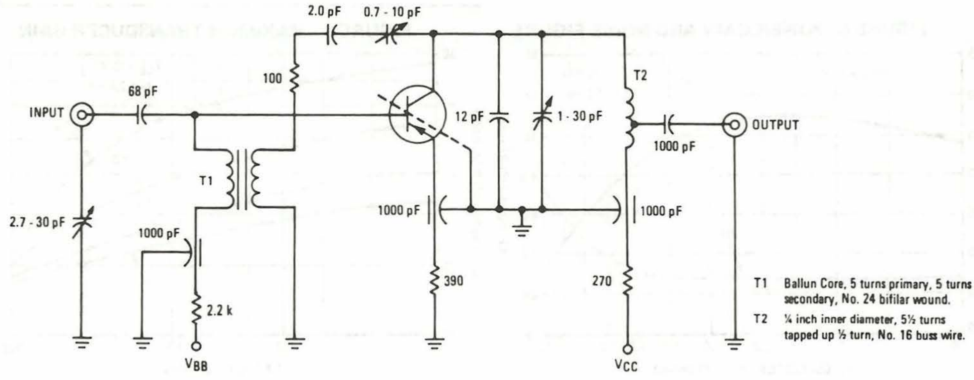
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	25	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	—	10	nAdc
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	120	—
Base-Emitter On Voltage (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	—	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	1200	MHz
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	4.0	pF
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	1.0	pF
Collector Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)	$r_b'C_c$	—	10	ps
Noise Figure (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, R_S = 75 ohms, f = 100 MHz, BW = 1.0 MHz)	NF	—	3.0	dB
FUNCTIONAL TEST				
Amplifier Power Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	G_{pe}	22	—	dB

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

FIGURE 1 - 100 MHz POWER GAIN AND NOISE FIGURE TEST CIRCUIT



COMMON-EMITTER Y PARAMETERS (Polar Plots)

$V_{CE} = 10$ Vdc, $T_A = 25^oC$

FIGURE 2 - INPUT ADMITTANCE

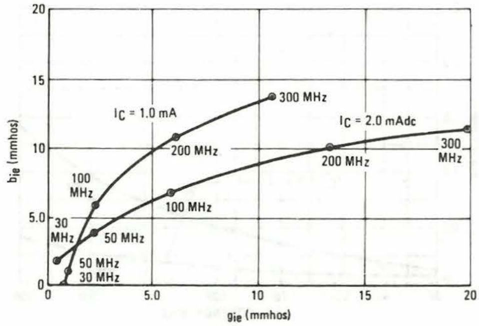


FIGURE 3 - OUTPUT ADMITTANCE

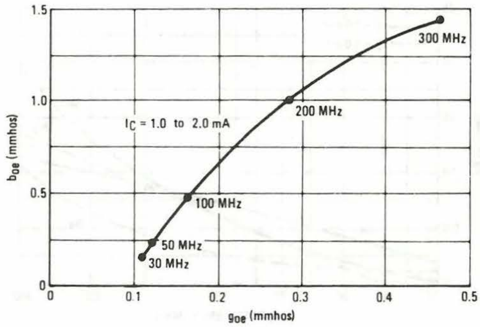


FIGURE 4 - FORWARD TRANSFER ADMITTANCE

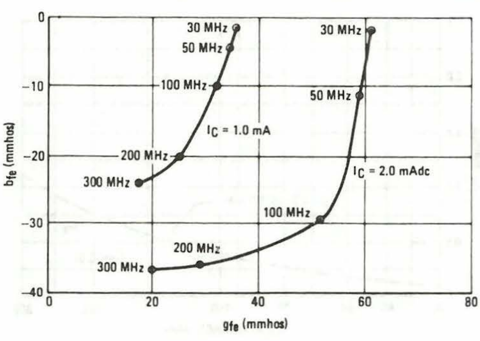
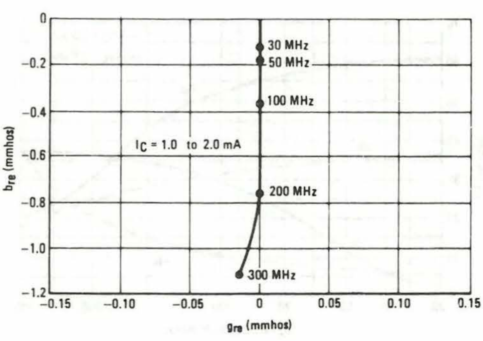


FIGURE 5 - REVERSE TRANSFER ADMITTANCE



2

STABILITY FACTOR CURVE

FIGURE 6 - POWER GAIN AND NOISE FIGURE

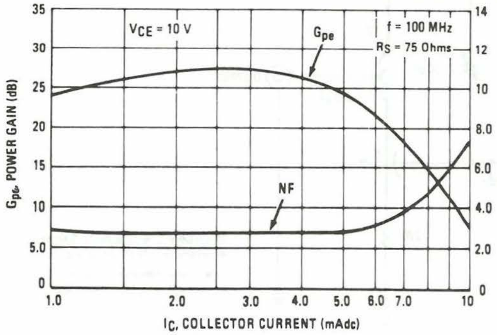
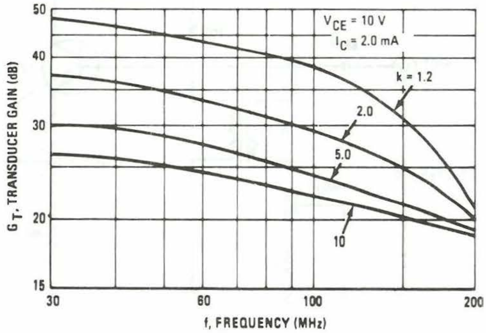


FIGURE 7 - MAXIMUM TRANSDUCER GAIN



COMMON-EMITTER Y PARAMETERS vs FREQUENCY

V_{CE} = 10 Vdc, T_A = 25°C

FIGURE 8 - INPUT ADMITTANCE

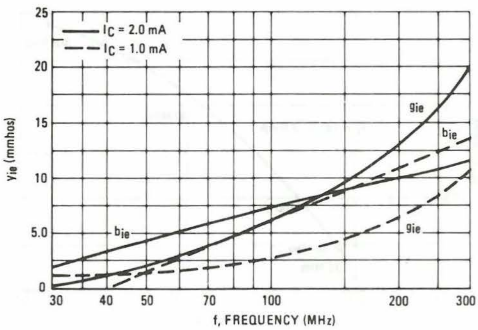


FIGURE 9 - OUTPUT ADMITTANCE

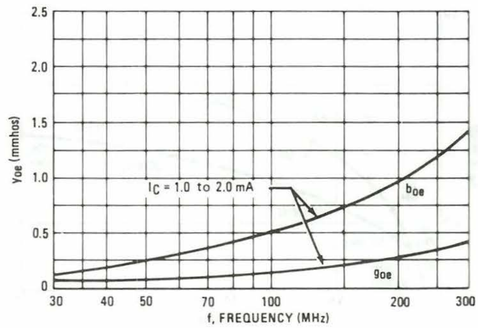


FIGURE 10 - FORWARD TRANSFER ADMITTANCE

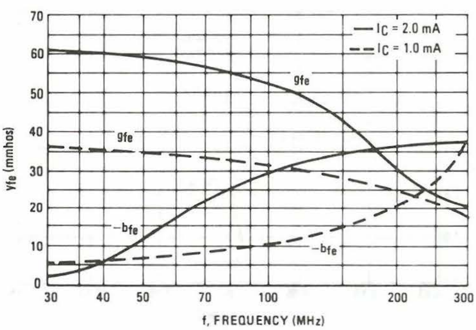
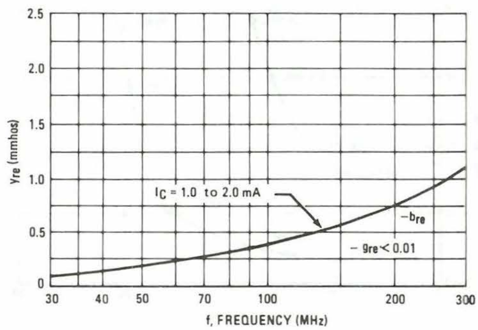


FIGURE 11 - REVERSE TRANSFER ADMITTANCE



STABILITY FACTOR CURVES

FIGURE 12 - OPTIMUM SOURCE ADMITTANCE

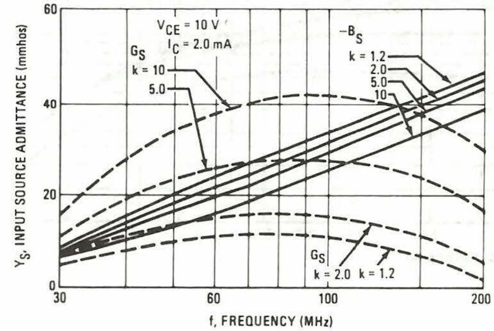
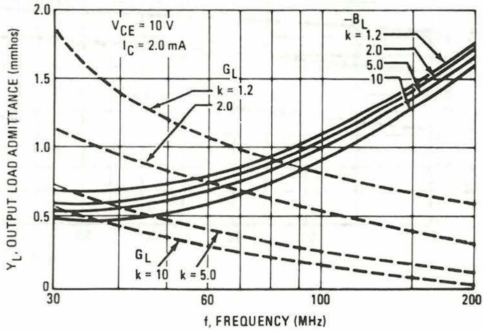


FIGURE 13 - OPTIMUM LOAD ADMITTANCE



When a potentially unstable device is operated without feedback, there is an infinite number of combinations of source and load admittance associated with any given circuit stability factor (k). Equations have been developed for determining the optimum source and load admittance for maximum gain. Figures 7, 12 and 13 provide a solution to the equations for the 2N5208.

NOISE FIGURE

FIGURE 14 - FREQUENCY EFFECTS

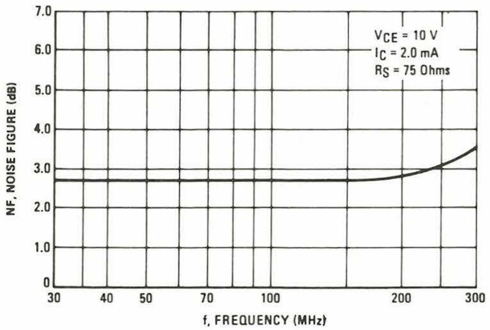


FIGURE 15 - SOURCE RESISTANCE EFFECTS

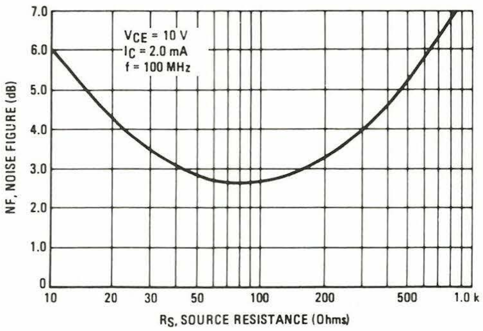


FIGURE 16 - CURRENT-GAIN — BANDWIDTH PRODUCT

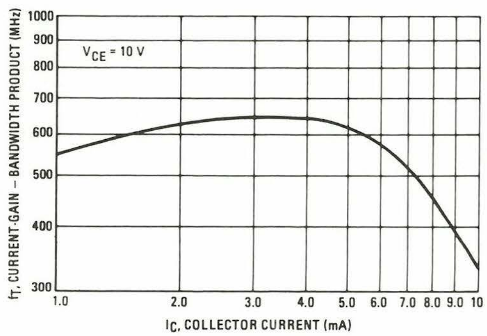


FIGURE 17 - CAPACITANCES

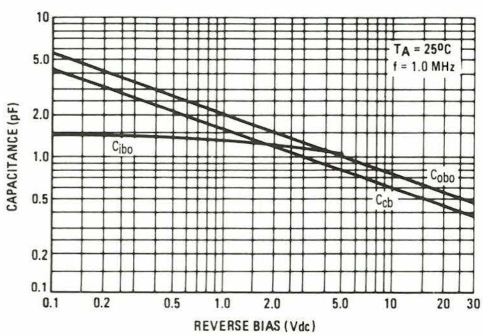
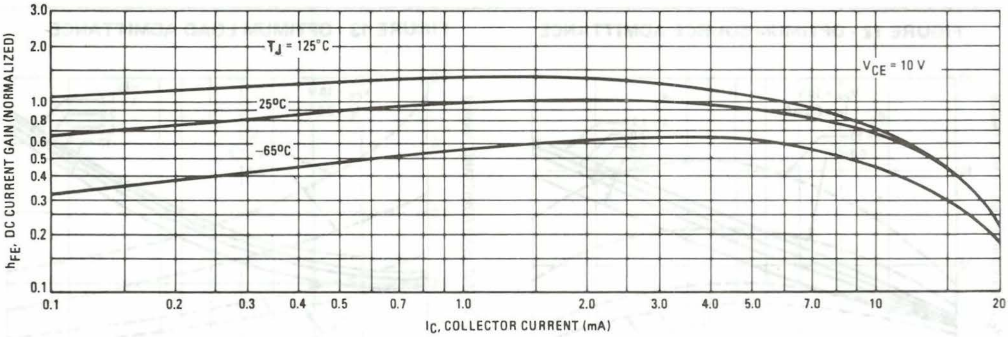


FIGURE 18 - DC CURRENT GAIN



2N5209
2N5210

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MPSA18 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CBO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	50	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)		$V_{(BR)CBO}$	50	—	Vdc
Collector Cutoff Current ($V_{CB} = 35$ Vdc, $I_E = 0$)		I_{CBO}	—	50	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
($I_C = 100\ \mu$Adc, $V_{CE} = 5.0$ Vdc)	2N5209 2N5210		100 200	300 600	
($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)	2N5209 2N5210		150 250	— —	
($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)(2)	2N5209 2N5210		150 250	— —	
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)		$V_{CE(sat)}$	—	0.7	Vdc
Base-Emitter On Voltage ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)		$V_{BE(on)}$	—	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 500\ \mu$Adc, $V_{CE} = 5.0$ Vdc, f = 20 MHz)		f_T	30	—	MHz
Collector-Base Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 100 kHz)		C_{cb}	—	4.0	pF
Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz)	2N5209 2N5210	h_{fe}	150 250	600 900	—
Noise Figure		NF			dB
($I_C = 20\ \mu$Adc, $V_{CE} = 5.0$ Vdc, $R_S = 22$ k ohms, f = 10 Hz to 15.7 kHz)	2N5209 2N5210		— —	3.0 2.0	
($I_C = 20\ \mu$Adc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ k ohms, f = 1.0 kHz)	2N5209 2N5210		— —	4.0 3.0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

2N5222

CASE 29-02, STYLE 2
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR
NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	2.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	15	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	20	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	2.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 10$ Vdc, $I_E = 0$)	I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{BE} = 2.0$ Vdc, $I_C = 0$)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain(2) ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	20	150	—
Collector-Emitter Saturation Voltage ($I_C = 4.0$ mAdc, $I_B = 400$ μAdc)	$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter On Voltage ($I_C = 4.0$ mAdc, $I_B = 400$ μAdc)	$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)	f_T	450	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	—	1.3	pF
Small-Signal Current Gain ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{fe}	20	300	—

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width ≈ 300 μs, Duty Cycle ≈ 2.0%.

COMMON-BASE y PARAMETERS versus FREQUENCY
(V_{CB} = 10 Vdc, I_C = 4.0 mAdc, T_A = 25°C)

y_{ib}, INPUT ADMITTANCE

FIGURE 1 – RECTANGULAR FORM

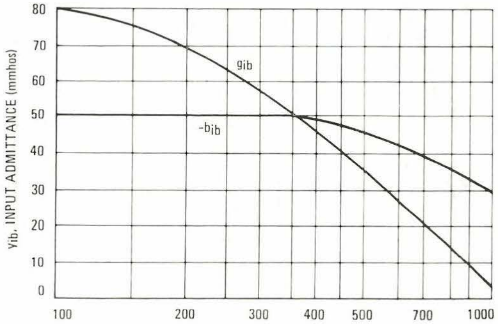
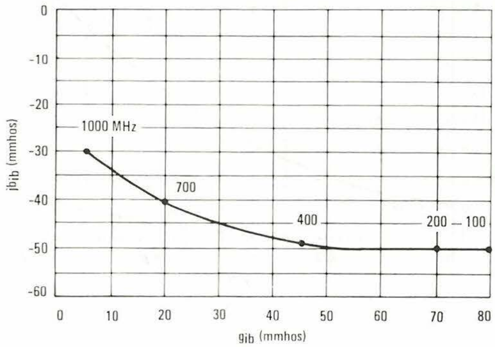


FIGURE 2 – POLAR FORM



y_{fb}, FORWARD TRANSFER ADMITTANCE

FIGURE 3 – RECTANGULAR FORM

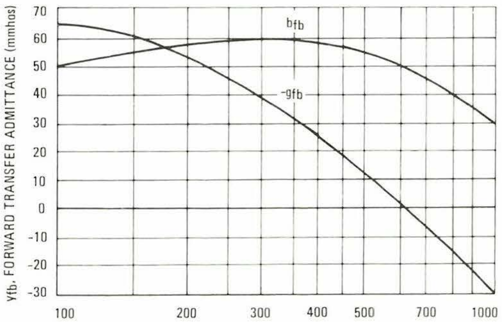
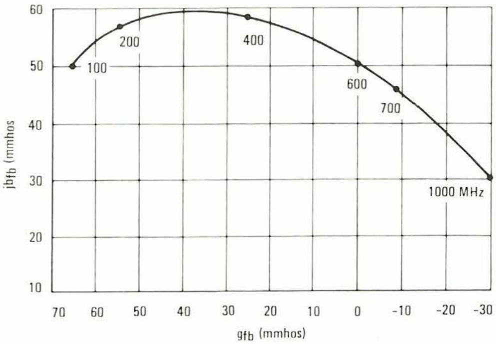


FIGURE 4 – POLAR FORM



COMMON-BASE y PARAMETERS versus FREQUENCY
(V_{CB} = 10 Vdc, I_C = 4.0 mAdc, T_A = 25°C)

y_{rb}, REVERSE TRANSFER ADMITTANCE

FIGURE 5 – RECTANGULAR FORM

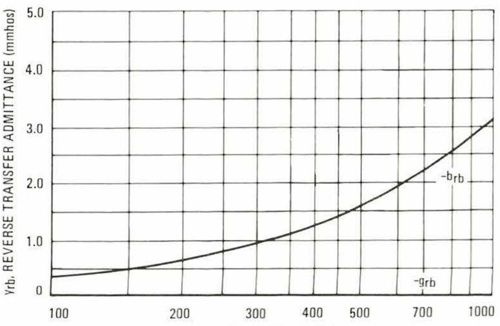
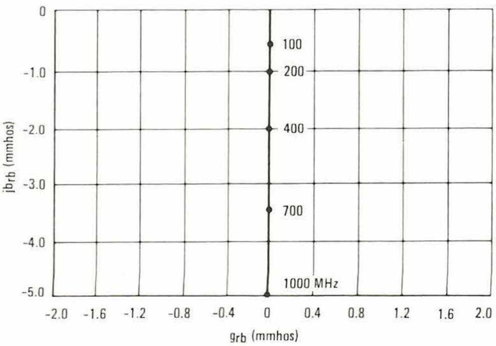


FIGURE 6 – POLAR FORM



y_{ob}, OUTPUT ADMITTANCE

FIGURE 7 – RECTANGULAR FORM

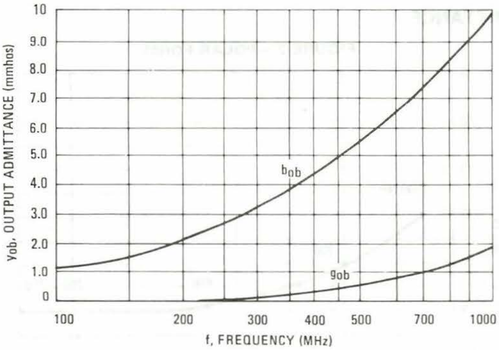
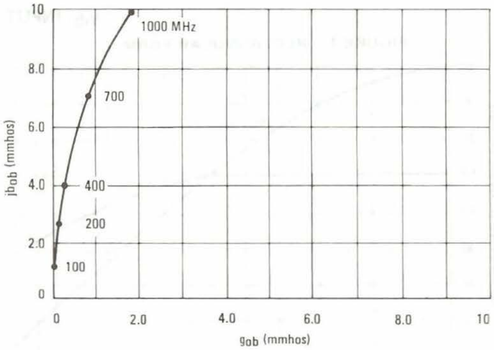


FIGURE 8 – POLAR FORM



2N5223

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N3903 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	20	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	25	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 10$ Vdc, $I_E = 0$)	I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	500	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	50	800	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	0.7	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)	f_T	150	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	—	4.0	pF
Small-Signal Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{fe}	50	1600	—

2

2N5224

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W

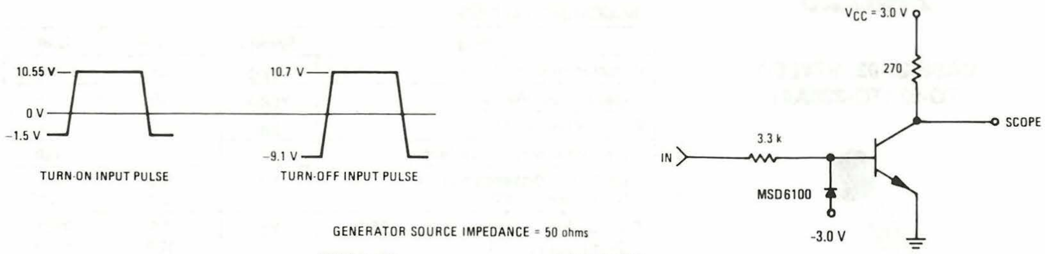
(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$	12	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		$V_{(BR)CBO}$	25	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)		I_{CBO}	—	500	nAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)		I_{EBO}	—	100	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)(2)		h_{FE}	 40 15	 400 —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 3.0 mAdc)		$V_{CE(sat)}$	—	0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 3.0 mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	250	—	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	—	4.0	pF
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 1.5 Vdc I_C = 10 mAdc, I_{B1} = 3.0 mAdc)	t_d	—	25	ns
Rise Time		t_r	—	20	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mA, I_{B1} = I_{B2} = 3.0 mAdc)	t_s	—	35	ns
Fall Time		t_f	—	25	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



GENERATOR SOURCE IMPEDANCE = 50 ohms

INPUT PULSE:
- RISE TIME ≤ 2.0 ns
- FALL TIME ≤ 2.0 ns
- NOMINAL PULSEWIDTH = 300 ns
- NOMINAL DUTY CYCLE = 2.0%

OSCILLOSCOPE:
- RISE TIME ≤ 0.4 ns
- INPUT RESISTANCE ≥ 50 ohms
- INPUT CAPACITANCE ≤ 4.0 pF

For t_d and t_r, diode is disconnected.

2N5225

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	25	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	25	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	300	nAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	500	nAdc
ON CHARACTERISTICS(2)				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 50 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 25 30	 — 600	—
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	—	0.8	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	50	—	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	20	pF
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	30	1800	—

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N5226

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	25	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	25	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_C = 0)	I_{CBO}	—	300	nAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	500	nAdc
ON CHARACTERISTICS(2)				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 50 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 25 30	 — 600	—
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	—	0.8	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	50	—	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	20	pF
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	30	1800	—

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

2N5227

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N3905 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	—	100	nAdc
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)	I_{EBO}	—	500	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 100 μAdc, V_{CE} = 10 Vdc) (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 30 50	 — 700	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	100	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	5.0	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	50	1500	—

2N5228

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

SWITCHING TRANSISTOR

PNP SILICON

Refer to MPS3640 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	5.0	Vdc
Collector-Emitter Voltage	V_{CES}	6.0	Vdc
Collector-Base Voltage	V_{CBO}	5.0	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

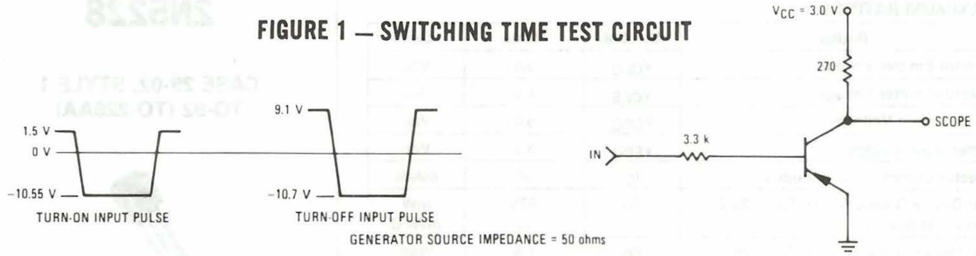
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	5.0	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100$ μAdc, $V_{BE} = 0$)		$V_{(BR)CES}$	6.0	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)		$V_{(BR)CBO}$	5.0	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 4.0$ Vdc, $V_{BE} = 0$)		I_{CES}	—	100	nAdc
Emitter Cutoff Current ($V_{BE} = 2.5$ Vdc, $I_C = 0$)		I_{EBO}	—	100	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 0.3$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc)(2)		h_{FE}	30 15	— —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 3.0$ mAdc)		$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 3.0$ mAdc)		$V_{BE(sat)}$	0.65	1.25	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)		f_T	300	—	MHz
Collector-Base Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{cb}	—	5.0	pF
SWITCHING CHARACTERISTICS					
Delay Time	($V_{CC} = 3.0$ Vdc, $V_{BE(off)} = 1.5$ Vdc $I_C = 10$ mAdc, $I_{B1} = 3.0$ mAdc)	t_d	—	25	ns
Rise Time		t_r	—	50	ns
Storage Time	($V_{CC} = 3.0$ Vdc, $I_C = 10$ mA, $I_{B1} = I_{B2} = 3.0$ mAdc)	t_s	—	90	ns
Fall Time		t_f	—	50	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



GENERATOR SOURCE IMPEDANCE = 50 ohms

INPUT PULSE:
- RISE TIME ≤ 2.0 ns
- FALL TIME ≤ 2.0 ns
- NOMINAL PULSEWIDTH = 300 ns
- NOMINAL DUTY CYCLE = 2.0%

OSCILLOSCOPE:
- RISE TIME ≤ 0.4 ns
- INPUT RESISTANCE ≥ 50 ohms
- INPUT CAPACITANCE ≤ 4.0 pF

2N5400
2N5401

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

PNP SILICON

2

MAXIMUM RATINGS

Rating	Symbol	2N5400	2N5401	Unit
Collector-Emitter Voltage	V_{CEO}	120	150	Vdc
Collector-Base Voltage	V_{CBO}	130	160	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	 2N5400 2N5401	$V_{(BR)CEO}$	 120 150	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	 2N5400 2N5401	$V_{(BR)CBO}$	 130 160	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 100$ Vdc, $I_E = 0$) ($V_{CB} = 120$ Vdc, $I_E = 0$) ($V_{CB} = 100$ Vdc, $I_E = 0$, $T_A = 100°C$) ($V_{CB} = 120$ Vdc, $I_E = 0$, $T_A = 100°C$)	 2N5400 2N5401 2N5400 2N5401	I_{CBO}	 — — — —	 100 50 100 50	 nAdc μAdc
Emitter Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 5.0$ Vdc)	 2N5400 2N5401 2N5400 2N5401 2N5400 2N5401	h_{FE}	 30 50 40 60 40 50	 — — 180 240 — —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{CE(sat)}$	 — —	 0.20 0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{BE(sat)}$	 — —	 1.0 1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 100 Mhz)	 2N5400 2N5401	f_T	 100 100	 400 300	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	6.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N5400 2N5401	h_{fe}	30 40	200 200	—
Noise Figure (I_C = 250 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kohm, f = 10 Hz to 15.7 kHz)		NF	—	8.0	dB

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

FIGURE 1 — DC CURRENT GAIN

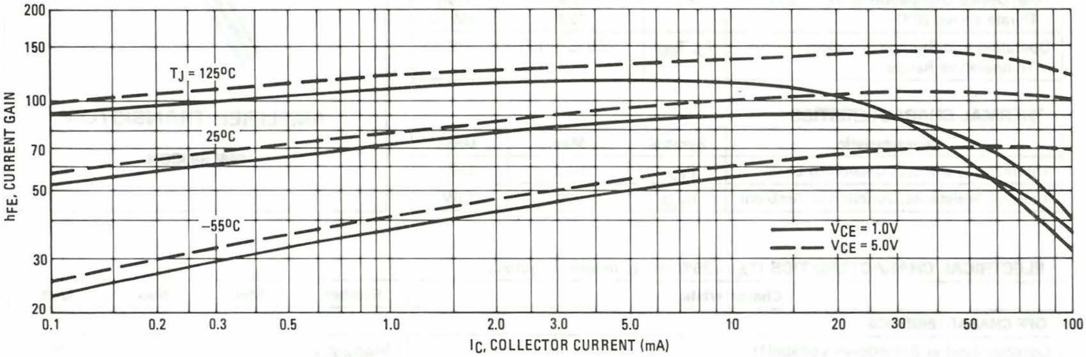


FIGURE 2 — COLLECTOR SATURATION REGION

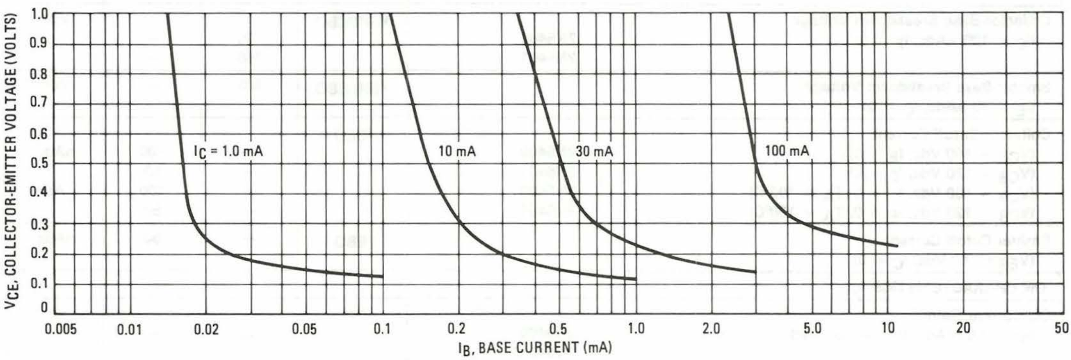


FIGURE 3 — COLLECTOR CUT-OFF REGION

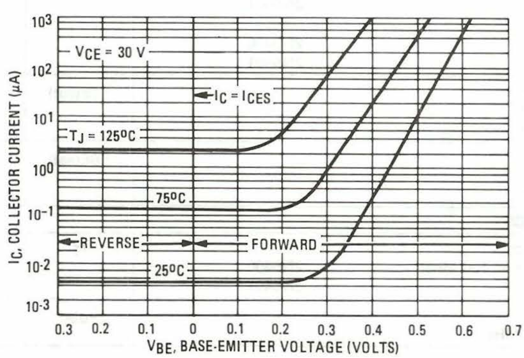


FIGURE 4 – "ON" VOLTAGES

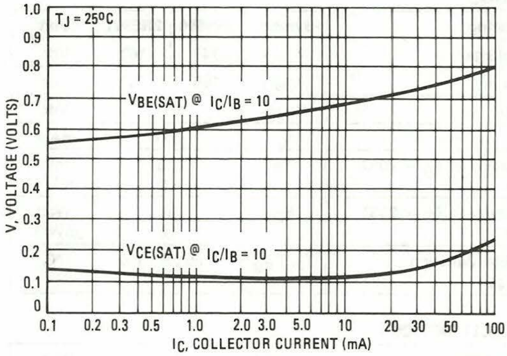


FIGURE 5 – TEMPERATURE COEFFICIENTS

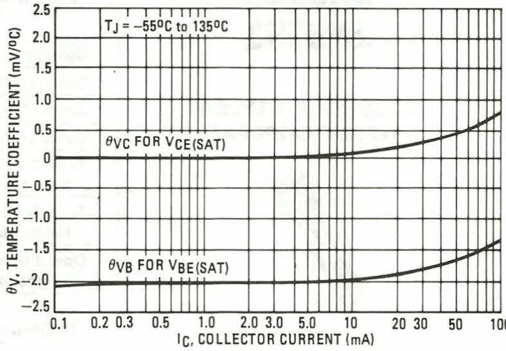


FIGURE 6 – SWITCHING TIME TEST CIRCUIT

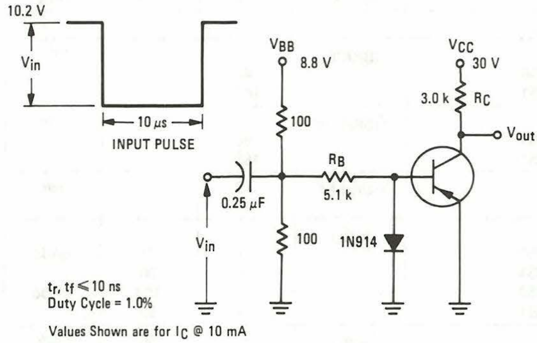


FIGURE 7 – CAPACITANCES

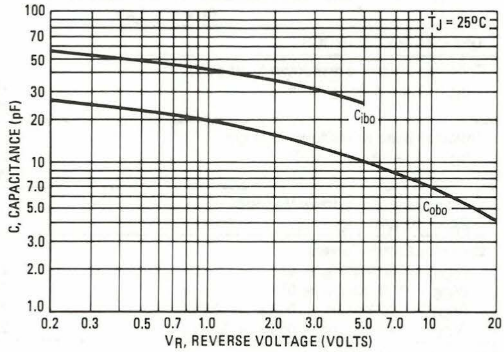


FIGURE 8 – TURN-ON TIME

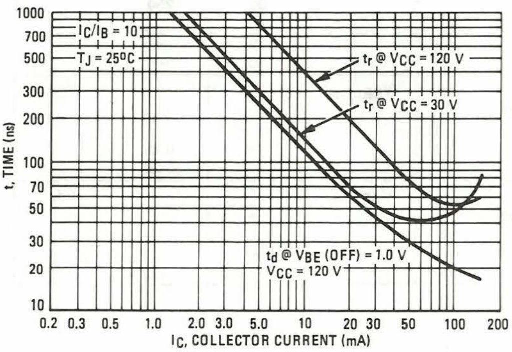
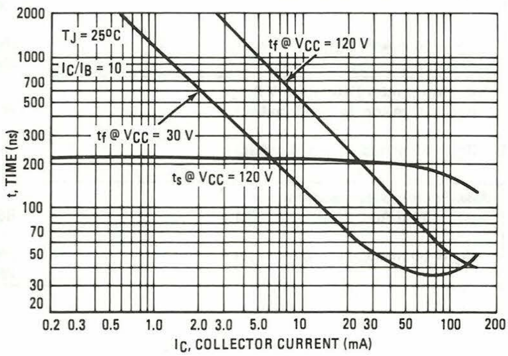


FIGURE 9 – TURN-OFF TIME



2N5550
2N5551

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N5550	2N5551	Unit
Collector-Emitter Voltage	V_{CEO}	140	160	Vdc
Collector-Base Voltage	V_{CBO}	160	180	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 1.0 mAdc, I_B = 0)	 2N5550 2N5551	$V_{(BR)CEO}$	 140 160	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 2N5550 2N5551	$V_{(BR)CBO}$	 160 180	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CB} = 100 Vdc, I_E = 0) (V_{CB} = 120 Vdc, I_E = 0) (V_{CB} = 100 Vdc, I_E = 0, T_A = 100°C) (V_{CB} = 120 Vdc, I_E = 0, T_A = 100°C)	 2N5550 2N5551 2N5550 2N5551	I_{CBO}	 — — — —	 100 50 100 50	 nAdc μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	—	50	nAdc
ON CHARACTERISTICS(2)					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	 2N5550 2N5551 2N5550 2N5551 2N5550 2N5551	h_{FE}	 60 80 60 80 20 30	 — — 250 250 — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	 Both Types 2N5550 2N5551	$V_{CE(sat)}$	 — — —	 0.15 0.25 0.20	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	 Both Types 2N5550 2N5551	$V_{BE(sat)}$	 — — —	 1.0 1.2 1.0	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	100	300	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	2N5550 2N5551	C_{ibo}	— —	30 20	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	50	200	—
Noise Figure (I_C = 250 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kohm, f = 10 Hz to 15.7 kHz)	2N5550 2N5551	NF	— —	10 8.0	dB

(2) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

FIGURE 1 — DC CURRENT GAIN

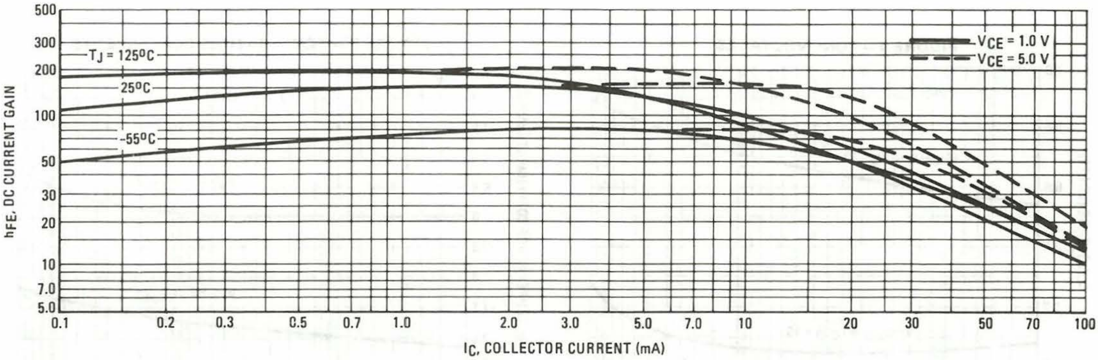


FIGURE 2 — COLLECTOR SATURATION REGION

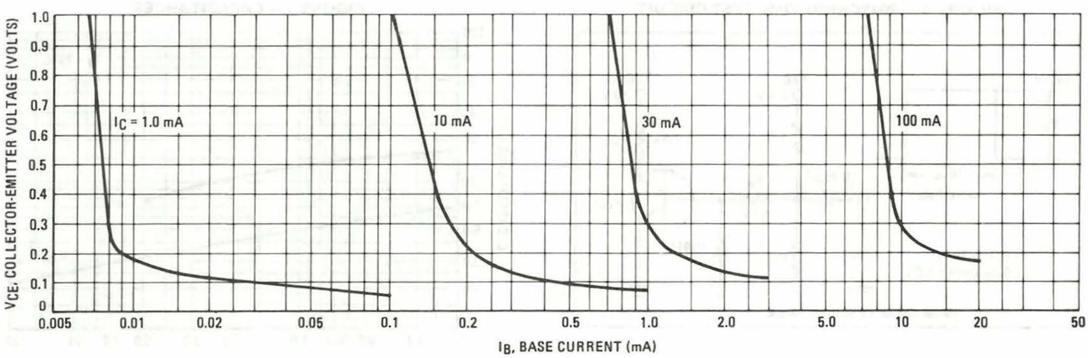


FIGURE 3 — COLLECTOR CUT-OFF REGION

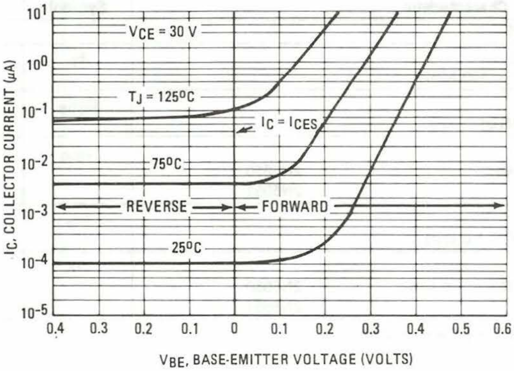


FIGURE 4 — "ON" VOLTAGES

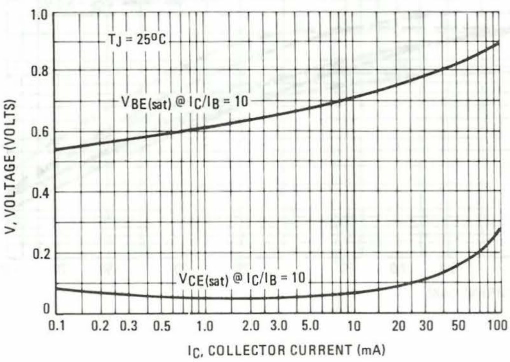


FIGURE 5 — TEMPERATURE COEFFICIENTS

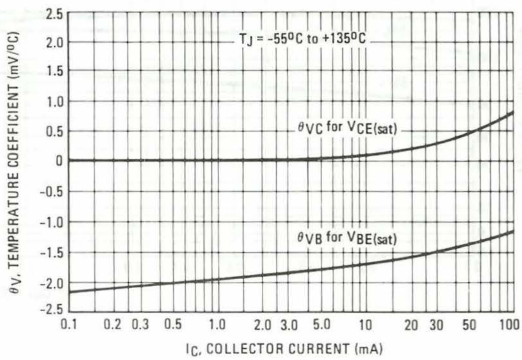


FIGURE 6 — SWITCHING TIME TEST CIRCUIT

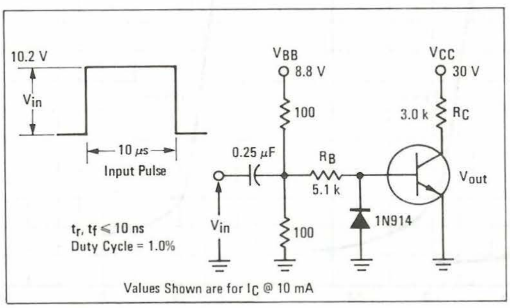


FIGURE 7 — CAPACITANCES

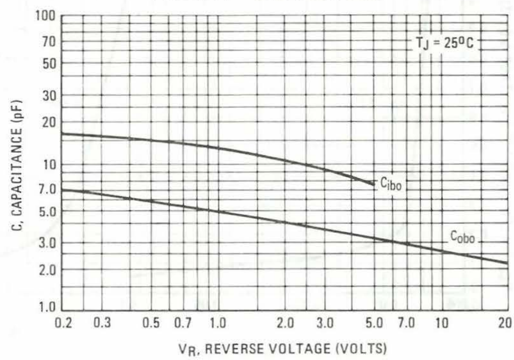


FIGURE 8 — TURN-ON TIME

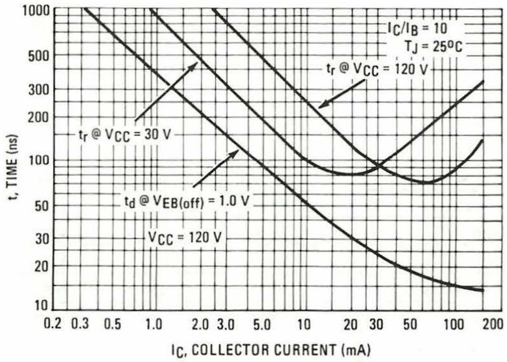
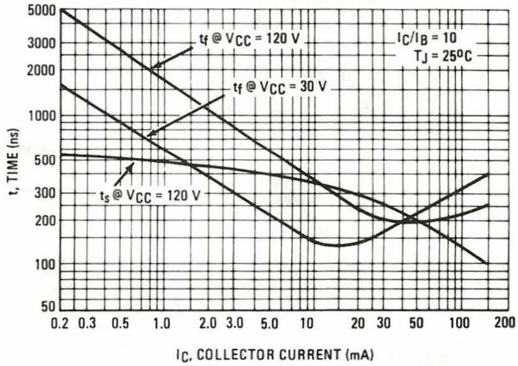


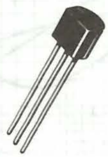
FIGURE 9 — TURN-OFF TIME



2

2N5771

CASE 29-02, STYLE 1
TO-92 (TO-226AA)



SWITCHING TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	15	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	Vdc
Collector Current — Continuous	I_C	50	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C
Lead Temperature	T_L	260	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 3.0 mA)(1)	$V_{(BR)CEO}$	15	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CES}$	15	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CBO}$	15	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μA)	$V_{(BR)EBO}$	4.5	—	Vdc
Collector Cutoff Current (V_{CB} = 8.0 Vdc)	I_{CBO}	—	10	nA
Collector Cutoff Current (V_{CE} = 8.0 Vdc) (V_{CE} = 8.0 Vdc, T_A = 125°C)	I_{CES}	— —	10 5.0	nA μA
Emitter Cutoff Current (V_{BE} = 4.5 Vdc)	I_{EBO}	—	1.0	μA
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 mA, V_{CE} = 0.5 Vdc)(1) (I_C = 10 mA, V_{CE} = 0.3 Vdc)(1) (I_C = 50 mA, V_{CE} = 1.0 Vdc)(1) (I_C = 10 mA, V_{CE} = 0.3 Vdc, T_A = −55°C)	h_{FE}	35 50 40 20	— 120 — —	—
Collector-Emitter Saturation Voltage(1) (I_C = 1.0 mA, I_B = 0.1 mA) (I_C = 10 mA, I_B = 1.0 mA) (I_C = 50 mA, I_B = 5.0 mA)	$V_{CE(sat)}$	— — —	0.15 0.18 0.6	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 1.0 mA, I_B = 0.1 mA) (I_C = 10 mA, I_B = 1.0 mA) (I_C = 50 mA, I_B = 5.0 mA)	$V_{BE(sat)}$	— 0.75 —	0.8 0.95 1.5	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, f = 140 kHz)	C_{cb}	—	3.0	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, f = 140 kHz)	C_{eb}	—	3.5	pF
Small-Signal Current Gain (I_C = 10 mA, V_{CE} = 10 Vdc, f = 100 MHz)	h_{fe}	8.5	—	—
SWITCHING CHARACTERISTICS				
Storage Time (I_C = 10 mA, I_{B1} ≈ I_{B2} ≈ 10 mA)	t_s	—	20	ns
Turn-On Time (I_C = 10 mA, I_B = 1.0 mA)	t_{on}	—	15	ns
Turn-Off Time (I_C = 10 mA, I_{B1} = I_{B2} = 1.0 mA)	t_{off}	—	20	ns

(1) Pulse Conditions: Pulse Length = 300 μs, Duty Cycle = 1.0%.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	12	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

2N6426
2N6427

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

DARLINGTON TRANSISTOR

NPN SILICON

2

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	12	—	—	Vdc
Collector Cutoff Current (V_{CE} = 25 Vdc, I_B = 0)		I_{CEO}	—	—	1.0	μAdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current (V_{BE} = 10 Vdc, I_C = 0)		I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS						
DC Current Gain(2) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	 2N6426 2N6427	h_{FE}	 20,000 10,000	 — —	 200,000 100,000	—
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	2N6426 2N6427		30,000 20,000	— —	300,000 200,000	
(I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	2N6426 2N6427		20,000 14,000	— —	200,000 140,000	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 0.5 mAdc) (I_C = 500 mAdc, I_B = 0.5 mAdc)		$V_{CE(sat)}$	 — —	 0.71 0.9	 1.2 1.5	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 0.5 mAdc)		$V_{BE(sat)}$	—	1.52	2.0	Vdc
Base-Emitter On Voltage (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	—	1.24	1.75	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	5.4	7.0	pF
Input Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	10	15	pF

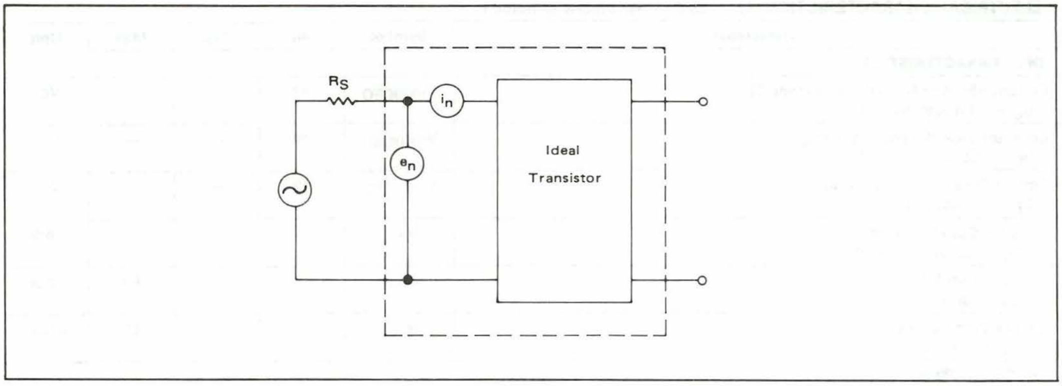
2

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Input Impedance (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N6426 2N6427	h_{ie}	100 50	— —	2000 1000	k Ω
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N6426 2N6427	h_{fe}	20,000 10,000	— —	— —	—
Current Gain — High Frequency (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	2N6426 2N6427	$\|h_{fe}\|$	1.5 1.3	2.4 2.4	— —	—
Output Admittance (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		h_{oe}	—	—	1000	μmhos
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, R_S = 100 kΩ, f = 10 kHz to 15.7 kHz)		NF	—	3.0	10	dB

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – TRANSISTOR NOISE MODEL



NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

FIGURE 2 – NOISE VOLTAGE

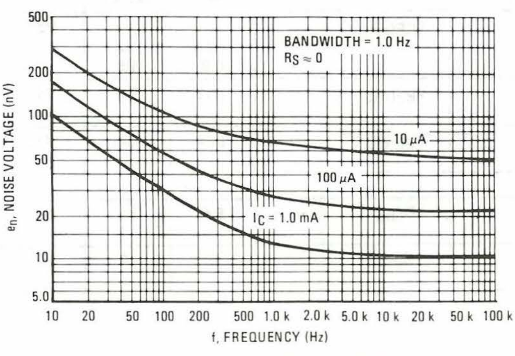


FIGURE 3 – NOISE CURRENT

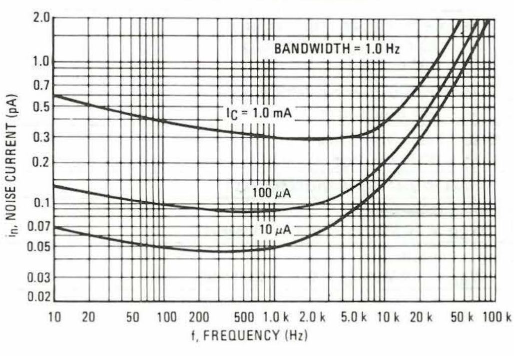


FIGURE 4 – TOTAL WIDEBAND NOISE VOLTAGE

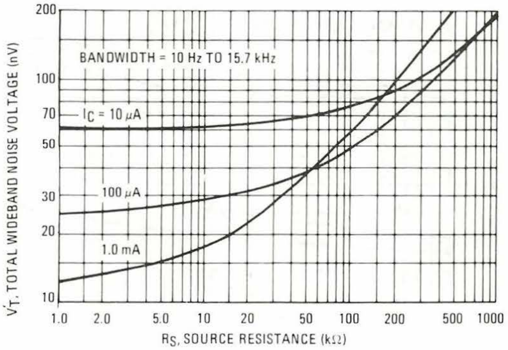
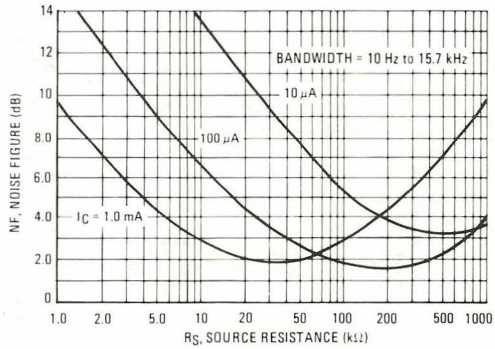


FIGURE 5 – WIDEBAND NOISE FIGURE



SMALL-SIGNAL CHARACTERISTICS

FIGURE 6 – CAPACITANCE

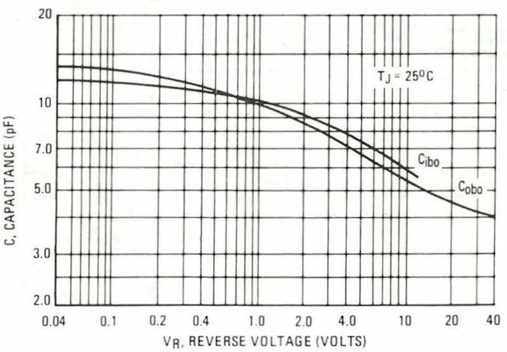


FIGURE 7 – HIGH FREQUENCY CURRENT GAIN

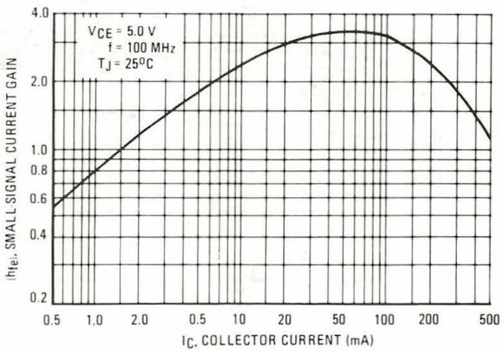


FIGURE 8 – DC CURRENT GAIN

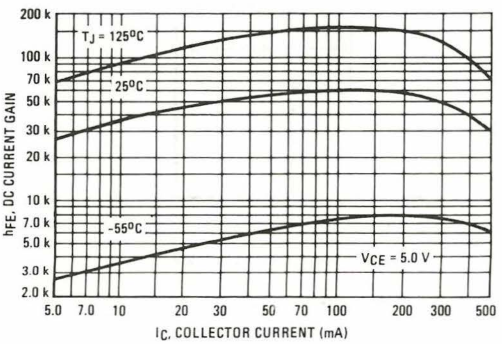
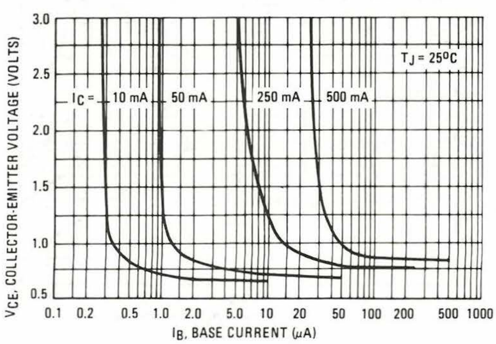


FIGURE 9 – COLLECTOR SATURATION REGION



2

FIGURE 10 – "ON" VOLTAGES

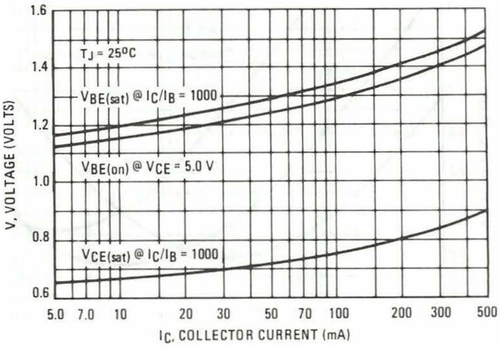


FIGURE 11 – TEMPERATURE COEFFICIENTS

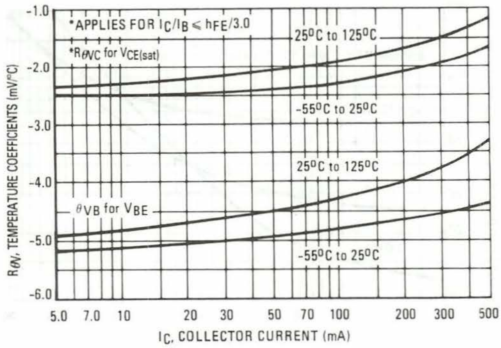


FIGURE 12 – THERMAL RESPONSE

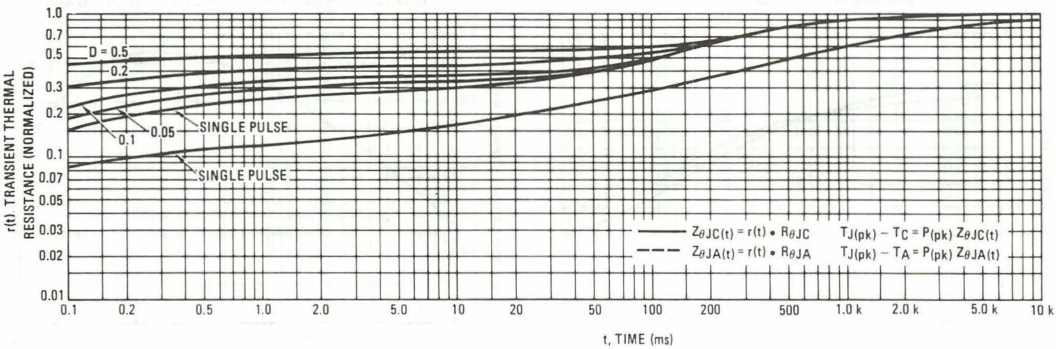
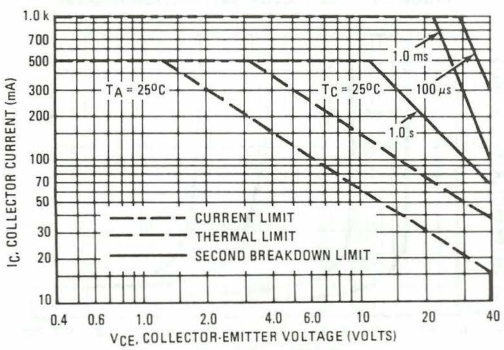
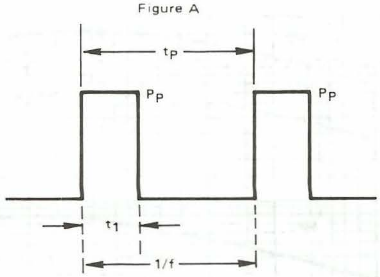


FIGURE 13 – ACTIVE REGION SAFE OPERATING AREA



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA

Figure A



Duty Cycle = $t_1 f = \frac{t_1}{t_P}$

Peak Pulse Power = P_P

2N6428,A
2N6429,A

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N6428 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage 2N6428,A 2N6429,A	V_{CEO}	 50 45	Vdc
Collector-Base Voltage 2N6428,A 2N6429,A	V_{CBO}	 60 55	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	 2N6428,A 2N6429,A	$V_{(BR)CEO}$	 50 45	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	 2N6428,A 2N6429,A	$V_{(BR)CBO}$	 60 55	 — —	Vdc
Collector Cutoff Current ($V_{CE} = 30$ Vdc)		I_{CEO}	—	0.025	μA
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)		I_{CBO}	—	0.01	μA
Emitter Cutoff Current ($V_{EB} = 5.0$ Vdc, $I_C = 0$)		I_{EBO}	—	0.01	μA
ON CHARACTERISTICS					
DC Current Gain ($V_{CE} = 5.0$ Vdc, $I_C = 0.01$ mAdc)	 2N6428,A 2N6429,A	h_{FE}	 250 500	 — —	—
($V_{CE} = 5.0$ Vdc, $I_C = 0.1$ mAdc)	2N6428,A 2N6429,A		250 500	650 1250	
($V_{CE} = 5.0$ Vdc, $I_C = 1.0$ mAdc)	2N6428,A 2N6429,A		250 500	— —	
($V_{CE} = 5.0$ Vdc, $I_C = 10$ mAdc)	2N6428,A 2N6429,A		250 500	— —	
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 0.5$ mAdc) ($I_C = 100$ mAdc, $I_B = 5.0$ mAdc)		$V_{CE(sat)}$	 — —	 0.2 0.6	Vdc
Base-Emitter On Voltage ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)		$V_{BE(on)}$	0.56	0.66	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ V, f = 100 MHz)		f_T	100	700	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	3.0	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)		C_{ibo}	—	8.0	pF

2

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N6428,A 2N6429,A	h_{ie}	3.0 6.0	30 60	kΩ
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N6428,A 2N6429,A	h_{re}	2.0 5.0	20 50	$X\ 10^{-4}$
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N6428,A 2N6429,A	h_{fe}	200 400	800 1600	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N6428,A 2N6429,A	h_{oe}	5.0 10	50 100	μmhos

NOISE FIGURE/TOTAL NOISE VOLTAGE CHARACTERISTICS (V_{CE} = 5.0 V, I_C = 0.1 mA, T_A = 25°C).

	NF Max (1)	V_T Max (1)	NF Max (2)	V_T Max (2)	NF Max (3)	V_T Max (3)	Unit	
2N6428	3.0	18.1	6.0	5700	3.5	4.3	dB	nV
2N6428A	2.0	16.2	4.0	4600	3.0	4.1	dB	nV
2N6429	3.0	18.1	5.0	5100	4.0	4.6	dB	nV
2N6429A	2.0	16.2	3.5	4300	3.5	4.3	dB	nV

(1) R_S = 10 kΩ, BW = 1.0 Hz, f = 100 Hz
(2) R_S = 50 kΩ, BW = 15.7 kHz, f = 10 Hz–10 kHz
(3) R_S = 500 Ω, BW = 1.0 Hz, f = 10 Hz

MAXIMUM RATINGS

Rating	Symbol	2N6515 2N6518	2N6516 2N6519	2N6517 2N5520	Unit
Collector-Emitter Voltage	V_{CEO}	250	300	350	Vdc
Collector-Base Voltage	V_{CBO}	250	300	350	Vdc
Emitter-Base Voltage 2N6515, 2N6516, 2N6517 2N6518, 2N6519, 2N6520	V_{EBO}	 6.0 5.0			Vdc
Base Current	I_B	250			mAdc
Collector Current — Continuous	I_C	500			mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.625 5.0			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C
Lead Temperature ≥ 1/16" from case for 10 seconds	T_L	260			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

NPN
2N6515
thru 2N6517
PNP
2N6518
thru 2N6520

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTOR

2

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	 2N6515, 2N6518 2N6516, 2N6519 2N6517, 2N6520	$V_{(BR)CEO}$	 250 300 350	 — — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 2N6515, 2N6518 2N6516, 2N6519 2N6517, 2N6520	$V_{(BR)CBO}$	 250 300 350	 — — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	 2N6515, 2N6516, 2N6517 2N6518, 2N6519, 2N6520	$V_{(BR)EBO}$	 6.0 5.0	 — —	Vdc
Collector Cutoff Current (V_{CB} = 150 Vdc, I_E = 0) (V_{CB} = 200 Vdc, I_E = 0) (V_{CB} = 250 Vdc, I_E = 0)	 2N6515, 2N6518 2N6516, 2N6519 2N6517, 2N6520	I_{CBO}	 — — —	 50 50 50	nAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0) (V_{EB} = 4.0 Vdc, I_C = 0)	 2N6515, 2N6516, 2N6517 2N6518, 2N6519, 2N6520	I_{EBO}	 — —	 50 50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	 2N6515, 2N6518 2N6516, 2N6519 2N6517, 2N6520	h_{FE}	 35 30 20	 — — —	—
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N6515, 2N6518 2N6516, 2N6519 2N6517, 2N6520		50 45 30	— — —	
(I_C = 30 mAdc, V_{CE} = 10 Vdc)	2N6515, 2N6518 2N6516, 2N6519 2N6517, 2N6520		50 45 30	300 270 200	
(I_C = 50 mAdc, V_{CE} = 10 Vdc)	2N6515, 2N6518 2N6516, 2N6519 2N6517, 2N6520		45 40 20	220 200 200	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)	2N6515, 2N6518 2N6516, 2N6519 2N6517, 2N6520		25 20 15	— — —	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

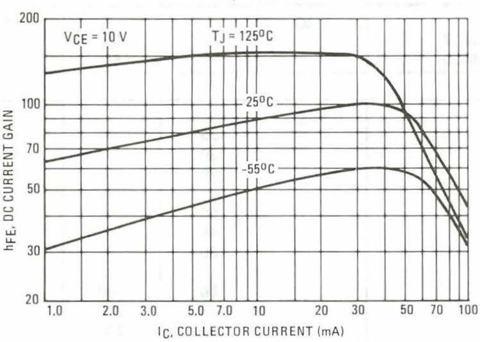
Characteristic	Symbol	Min	Max	Unit
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		—	0.30	
(I_C = 20 mAdc, I_B = 2.0 mAdc)		—	0.35	
(I_C = 30 mAdc, I_B = 3.0 mAdc)		—	0.50	
(I_C = 50 mAdc, I_B = 5.0 mAdc)		—	1.0	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		—	0.75	
(I_C = 20 mAdc, I_B = 2.0 mAdc)		—	0.85	
(I_C = 30 mAdc, I_B = 3.0 mAdc)		—	0.90	
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(1) (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	f_T	40	200	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}		6.0	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{eb}			pF
2N6515 thru 2N6517		—	80	
2N6518 thru 2N6520		—	100	
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 100 Vdc, $V_{BE(off)}$ = 2.0 Vdc, I_C = 50 mAdc, I_{B1} = 10 mAdc)	t_{on}	—	200	ns
Turn-Off Time (V_{CC} = 100 Vdc, I_C = 50 mAdc, I_{B1} = I_{B2} = 10 mAdc)	t_{off}	—	3.5	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – DC CURRENT GAIN

NPN

2N6515, 2N6516



PNP

2N6518, 2N6519

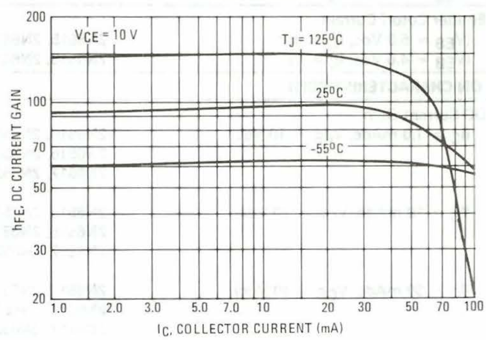
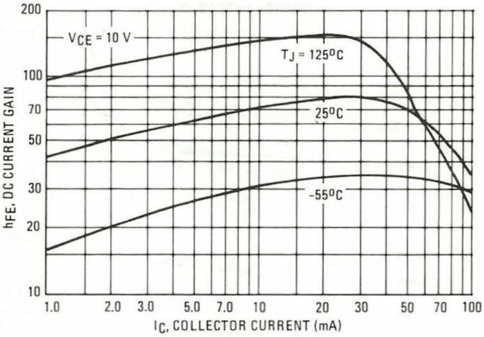


FIGURE 2 – DC CURRENT GAIN

2N6517



2N6520

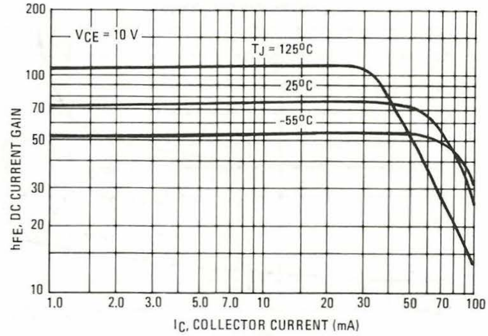
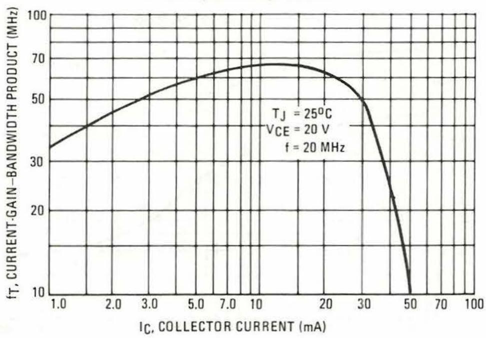


FIGURE 3 – CURRENT-GAIN – BANDWIDTH PRODUCT

2N6515, 2N6516, 2N6517



2N6518, 2N6519, 2N6520

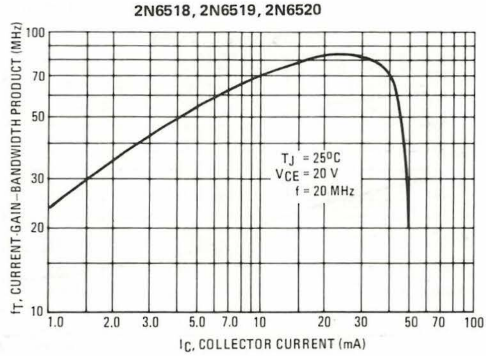
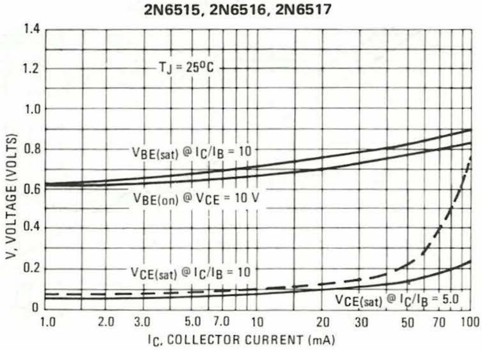


FIGURE 4 – "ON" VOLTAGES

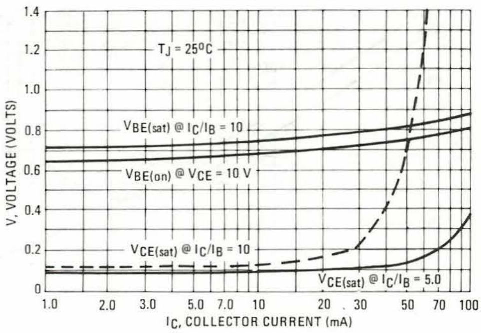
NPN

2N6515, 2N6516, 2N6517



PNP

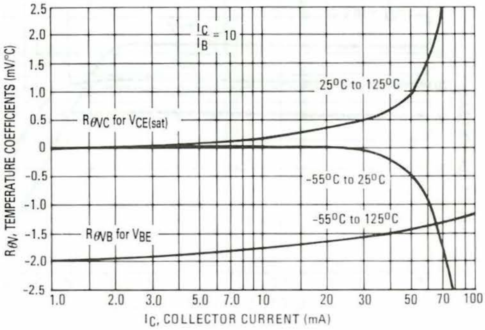
2N6518, 2N6519, 2N6520



2

FIGURE 5 — TEMPERATURE COEFFICIENTS

2N6515, 2N6516, 2N6517



2N6518, 2N6519, 2N6520

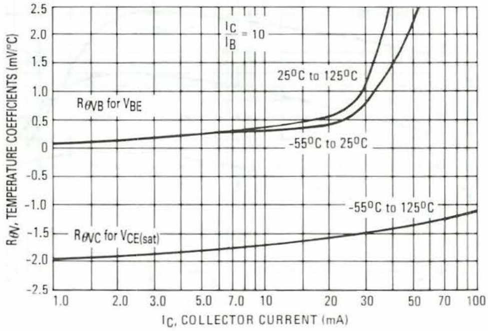
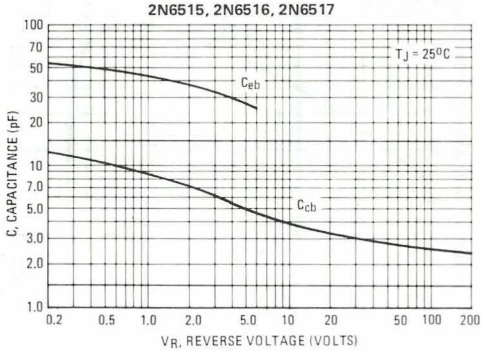
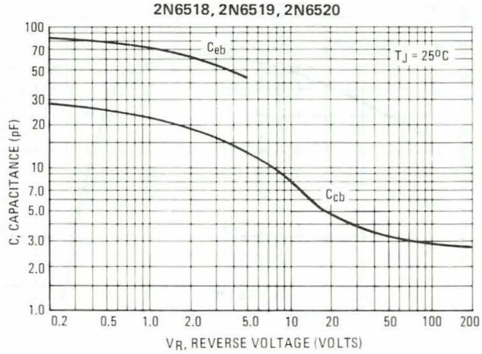


FIGURE 6 — CAPACITANCE

2N6515, 2N6516, 2N6517



2N6518, 2N6519, 2N6520

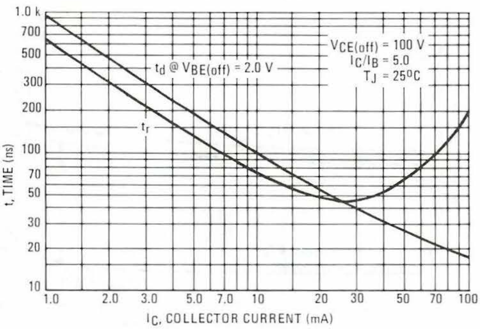


NPN

PNP

FIGURE 7 — TURN-ON TIME

2N6515, 2N6516, 2N6517



2N6518, 2N6519, 2N6520

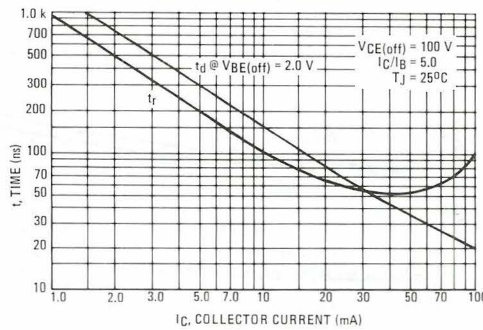
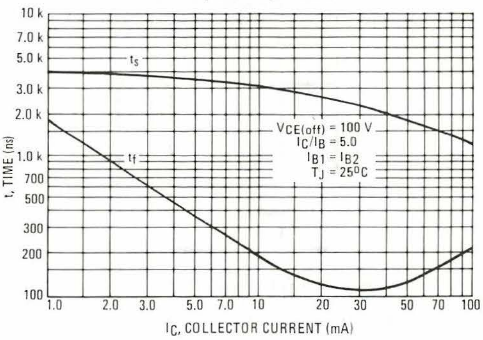


FIGURE 8 – TURN-OFF TIME



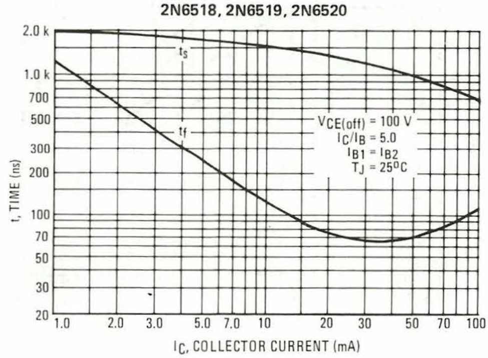


FIGURE 9 – SWITCHING TIME TEST CIRCUIT

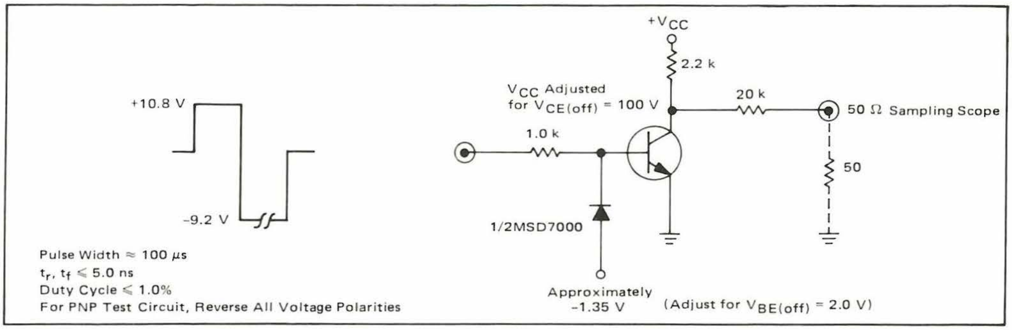
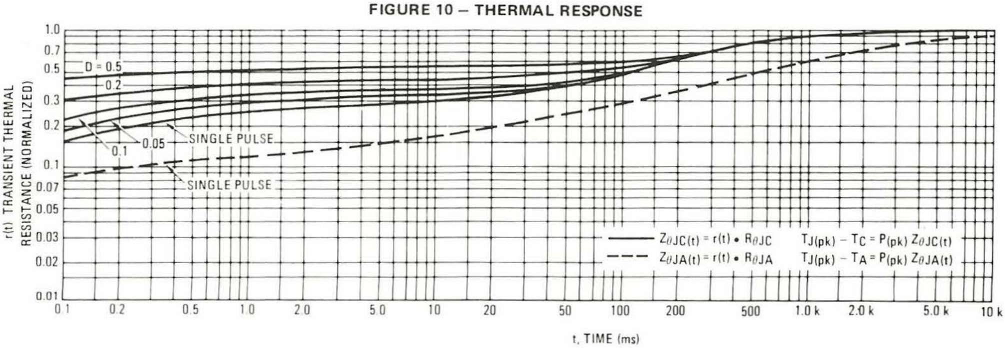
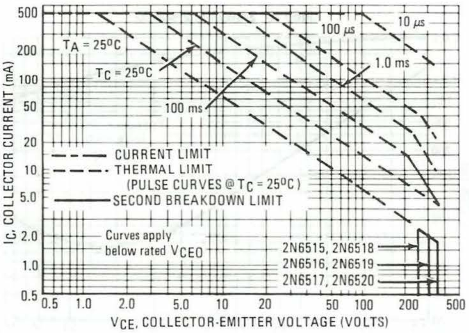


FIGURE 10 – THERMAL RESPONSE



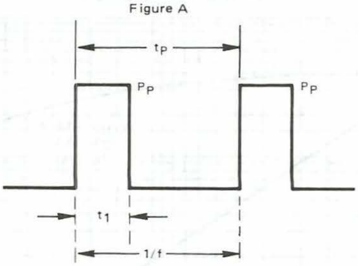
2

FIGURE 11 – ACTIVE REGION SAFE OPERATING AREA



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA

Figure A



Duty Cycle = $t_1 f = \frac{t_1}{t_P}$

Peak Pulse Power = P_P

MPS404
MPS404A

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

CHOPPER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MPS404	MPS404A	Unit
Collector-Emitter Voltage	V_{CEO}	24	35	Vdc
Collector-Base Voltage	V_{CBO}	25	40	Vdc
Emitter-Base Voltage	V_{EBO}	12	25	Vdc
Collector Current — Continuous	I_C	150		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)	 MPS404 MPS404A	$V_{(BR)CEO}$	 24 35	 — —	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	 MPS404 MPS404A	$V_{(BR)CBO}$	 25 40	 — —	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	 MPS404 MPS404A	$V_{(BR)EBO}$	 12 25	 50 50	 — —	Vdc
Collector Cutoff Current ($V_{CB} = 10$ Vdc, $I_E = 0$)		I_{CBO}	—	—	100	nAdc
Emitter Cutoff Current ($V_{BE} = 10$ Vdc, $I_C = 0$)		I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = 12$ mAdc, $V_{CE} = 0.15$ Vdc)		h_{FE}	30	100	400	—
Collector-Emitter Saturation Voltage ($I_C = 12$ mAdc, $I_B = 0.4$ mAdc) ($I_C = 24$ mAdc, $I_B = 1.0$ mAdc)		$V_{CE(sat)}$	 — —	 0.1 0.12	 0.15 0.20	Vdc
Base-Emitter Saturation Voltage ($I_C = 12$ mAdc, $I_B = 0.4$ mAdc) ($I_C = 24$ mAdc, $I_B = 1.0$ mAdc)		$V_{BE(sat)}$	 — —	 0.7 0.74	 0.85 1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Common-Base Cutoff Frequency ($I_C = 1.0$ mAdc, $V_{CB} = 6.0$ Vdc)		f_{ob}	4.0	—	—	MHz
Output Capacitance ($V_{CB} = 6.0$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	6.8	20	pF

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – COLLECTOR-EMITTER VOLTAGE

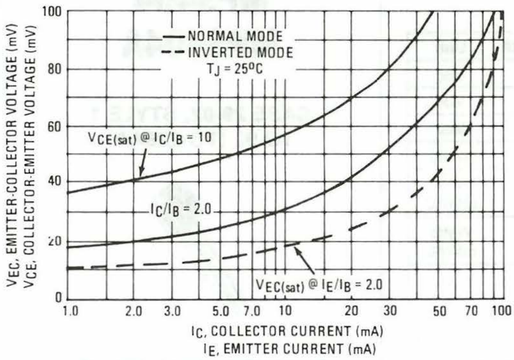
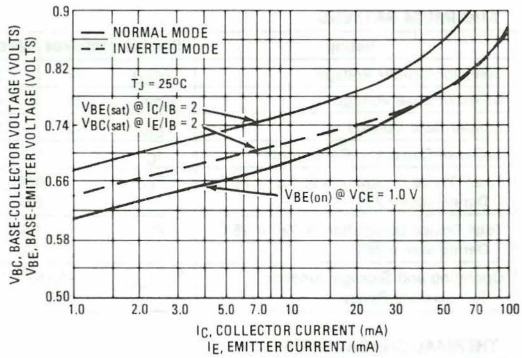


FIGURE 2 – BASE "ON" VOLTAGE



NORMAL MODE

FIGURE 3 – DC CURRENT GAIN @ $V_{CE} = 0.15$ Vdc

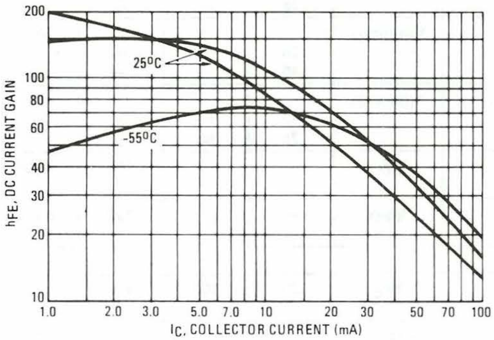
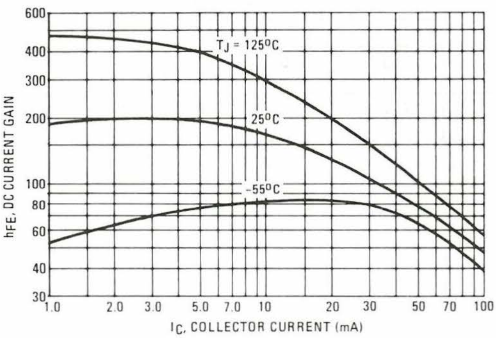


FIGURE 5 – DC CURRENT GAIN @ $V_{CE} = 1.0$ Vdc



INVERTED MODE

FIGURE 4 – DC CURRENT GAIN @ $V_{EC} = 0.15$ Vdc

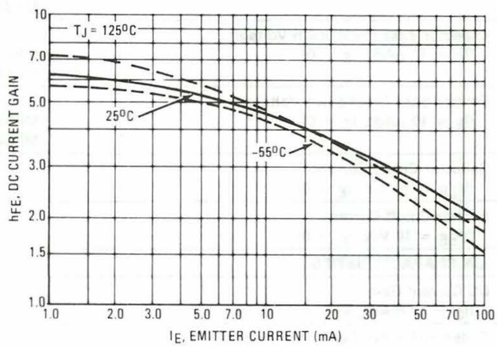


FIGURE 6 – DC CURRENT GAIN @ $V_{EC} = 1.0$ Vdc

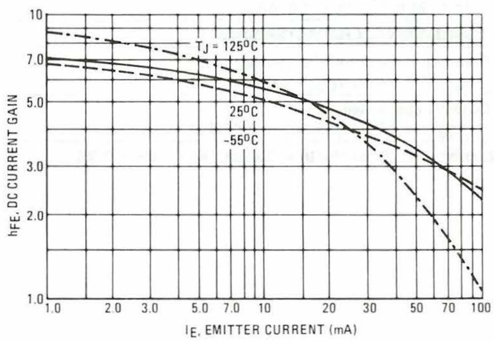


FIGURE 7 – COLLECTOR SATURATION REGION

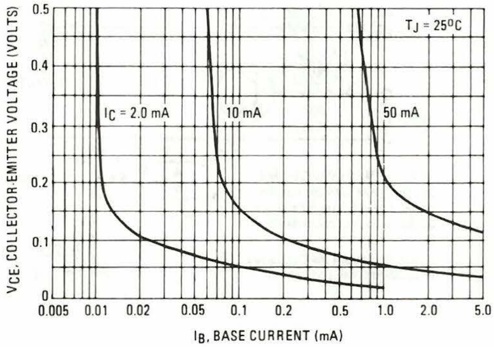


FIGURE 8 – EMITTER SATURATION REGION

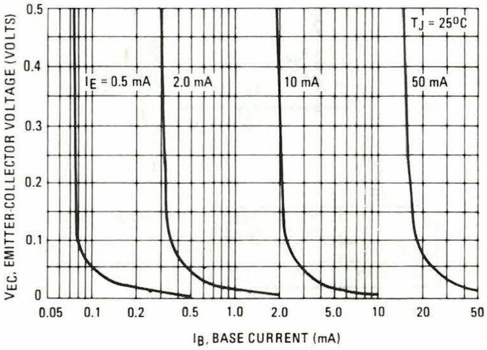


FIGURE 9 – EMITTER-COLLECTOR "ON" RESISTANCE

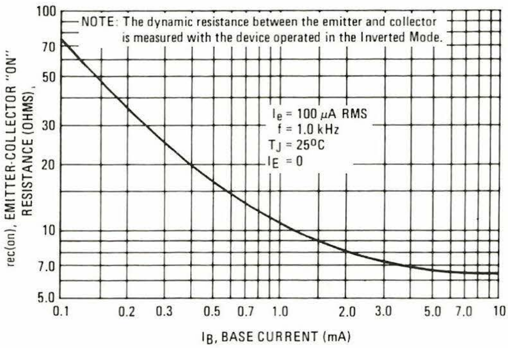


FIGURE 10 – CAPACITANCE

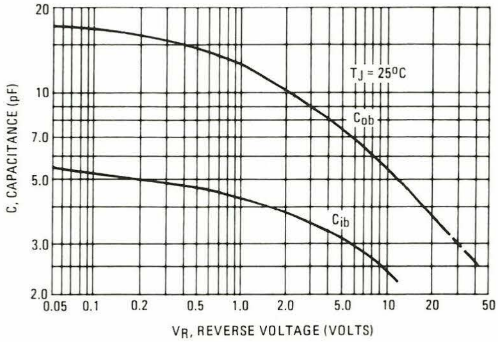


FIGURE 11 – TURN-ON TIME

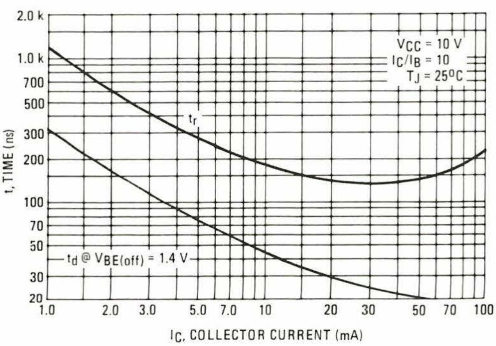
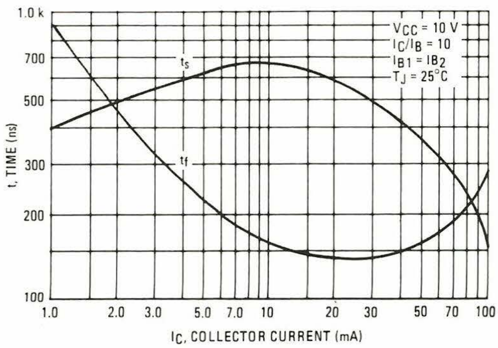
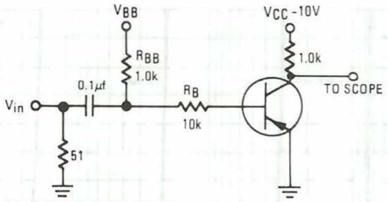


FIGURE 12 – TURN-OFF TIME



2

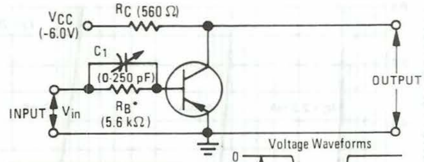
FIGURE 13 – SWITCHING TIME TEST CIRCUIT



	V_{in} (Volts)	V_{BB} (Volts)
t_{on}, t_d and t_r	-12	+1.4
t_{off}, t_s and t_f	+20.6	-11.6

Voltages and resistor values shown are for I_C = 10 mA, I_C/I_B = 10 and $I_{B1} = I_{B2}$. Resistor values changed to obtain curves in Figures 11 and 12.

FIGURE 14 – STORED BASE CHARGE TEST CIRCUIT



MEASUREMENT PROCEDURE
C_1 is increased until the t_{off} time of the output waveform is decreased to 0.2 μs, Q_S is then calculated by $Q_S = C_1 V_{in}$.
Q_{S3} or Q_{S7} by B-Line Electronics or equivalent may also be used.

MPS650
MPS651
NPN SILICON
MPS750
MPS751
PNP SILICON

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

MAXIMUM RATINGS

Rating	Symbol	MPS650 MPS750	MPS651 MPS751	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	2.0		Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 12.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 5.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	 MPS650, MPS750 MPS651, MPS751	$V_{(BR)CEO}$	 40 60	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	 MPS650, MPS750 MPS651, MPS751	$V_{(BR)CBO}$	 60 80	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 80$ Vdc, $I_E = 0$)	 MPS650, MPS750 MPS651, MPS751	I_{CBO}	 — —	 0.1 0.1	μAdc
Emitter Cutoff Current ($V_{EB} = 4.0$ V, $I_C = 0$)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 50$ mA, $V_{CE} = 2.0$ V) ($I_C = 500$ mA, $V_{CE} = 2.0$ V) ($I_C = 1.0$ A, $V_{CE} = 2.0$ V) ($I_C = 2.0$ A, $V_{CE} = 2.0$ V)		h_{FE}	 75 75 75 40	 — — — —	—
Collector-Emitter Saturation Voltage ($I_C = 2.0$ A, $I_B = 200$ mA) ($I_C = 1.0$ A, $I_B = 100$ mA)		$V_{CE(sat)}$	 — —	 0.5 0.3	Vdc
Base-Emitter Saturation Voltage ($I_C = 1.0$ A, $I_B = 100$ mA)		$V_{BE(sat)}$	—	1.2	Vdc
Base-Emitter On Voltage ($I_C = 1.0$ A, $V_{CE} = 2.0$ V)		$V_{BE(on)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 50$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)		f_T	75	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

MPS706,A

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CER}	20	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, R_{BE} = 10 Ohms)		$V_{(BR)CER}$	20	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		$V_{(BR)CBO}$	25	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 25 Vdc, I_E = 0)	 MPS706/MPS706A MPS706A	I_{CBO}	 — —	 — —	 0.5 10	μAdc
Collector Cutoff Current (V_{CE} = 20 Vdc, R_{BE} = 100 kHz)	MPS706A	I_{CER}	—	—	10	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0) (V_{BE} = 5.0 Vdc, I_C = 0)	 MPS706 MPS706A	I_{EBO}	 — —	 — —	 10 10	μAdc
ON CHARACTERISTICS						
DC Current Gain(2) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	 MPS706 MPS706A	h_{FE}	 20 20	 50 45	 — 60	—
Collector-Emitter Saturation Voltage(2) (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	—	0.3	0.6	Vdc
Base-Emitter Saturation Voltage(2) (I_C = 10 mAdc, I_B = 1.0 mAdc)	 MPS706 MPS706A	$V_{BE(sat)}$	 — 0.7	 0.8 0.8	 0.9 0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)		f_T	200	600	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	MPS706	C_{obo}	—	1.5	6.0	pF
Input Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	3.4	—	pF
Extrinsic Base Resistance (V_{CE} = 15 Vdc, I_E = 10 mAdc, f = 300 MHz)		r_b	—	—	50	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
SWITCHING CHARACTERISTICS						
Storage Time (Figure 1)		t_s				ns
(V_{CC} = 10 Vdc, I_C = 10 mAdc,	MPS706A		—	20	25	
I_{B1} = I_{B2} = 10 mAdc)	MPS706		—	20	60	
Turn-On Time (Figure 1) (V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 2.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc)		t_{on}	—	35	40	ns
Turn-Off Time (Figure 2) (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 3.0 mAdc)		t_{off}	—	55	75	ns

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width ≤ 12 ns, Duty Cycle ≤ 2.0%.

FIGURE 1 — SWITCHING TIME TEST CIRCUIT

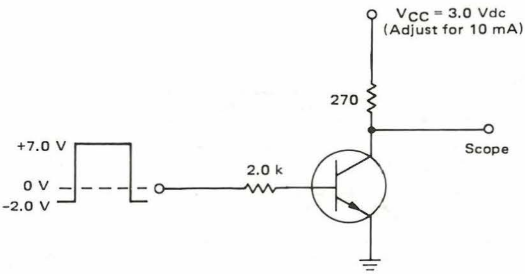
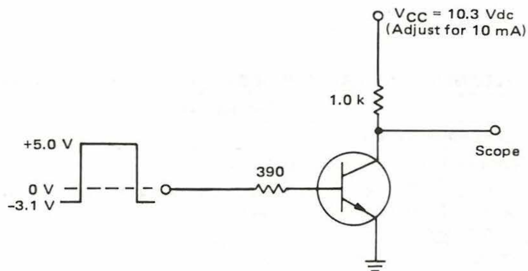


FIGURE 2 — STORAGE TIME TEST CIRCUIT



2

MPS708

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12 mW	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

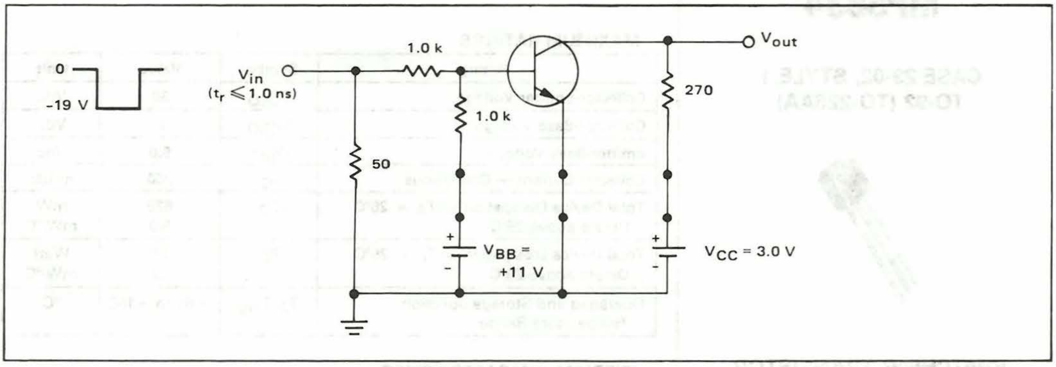
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 30 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 30 mAdc, R_{BE} = 10 Ohms)	$V_{(BR)CER}$	20	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	—	25	nAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	—	80	nAdc
ON CHARACTERISTICS(2)					
DC Current Gain (I_C = 0.5 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 15 30	 35 50	 — 120	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.21	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	0.68	0.7	0.78	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	600	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{obo}	—	2.4	6.0	pF
SWITCHING CHARACTERISTICS					
Storage Time (Figure 1) (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 10 mAdc)	t_s	—	14	25	ns

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPS750, MPS751

For Sepcifications, See MPS650, MPS651

FIGURE 1 – SWITCHING TIME TEST CIRCUIT



2

MPS834

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage ($I_C = 10\ \mu Adc$, $I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu Adc$, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)	I_{CBO}	—	—	0.5	μAdc
Collector Cutoff Current ($V_{CE} = 30$ Vdc, $V_{BE} = 0$)	I_{CES}	—	—	10	μAdc
ON CHARACTERISTICS					
DC Current Gain(2) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	25	—	—	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)(2)	$V_{CE(sat)}$	 — —	 0.2 0.3	 0.25 0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	—	0.7	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	350	600	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	1.5	4.0	pF
Input Capacitance ($V_{EB} = 10$ Vdc, $I_C = 0$, f = 100 kHz)	C_{ibo}	—	3.4	—	pF
SWITCHING CHARACTERISTICS					
Storage Time (Figure 1) ($V_{CC} = 10$ Vdc, $I_C = 10$ mAdc, $I_{B1} = I_{B2} = 10$ mAdc)	t_s	—	18	25	ns
Turn-On Time (Figure 1) ($V_{CC} = 3.0$ Vdc, $V_{BE(off)} = 4.0$ Vdc, $I_C = 10$ mAdc, $I_{B1} = 3.0$ mAdc)	t_{on}	—	12	16	ns
Turn-Off Time (Figure 2) ($V_{CC} = 3.0$ Vdc, $I_C = 10$ mAdc, $I_{B1} = 3.0$ mAdc)	t_{off}	—	25	30	ns

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT

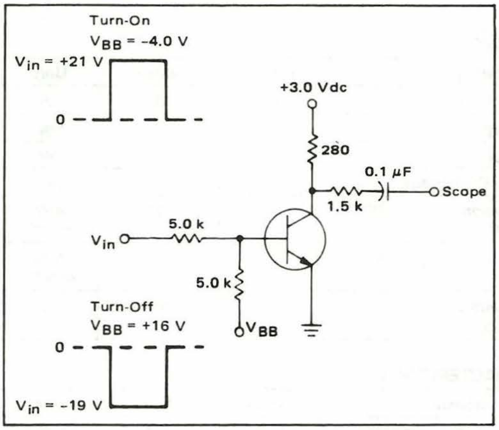
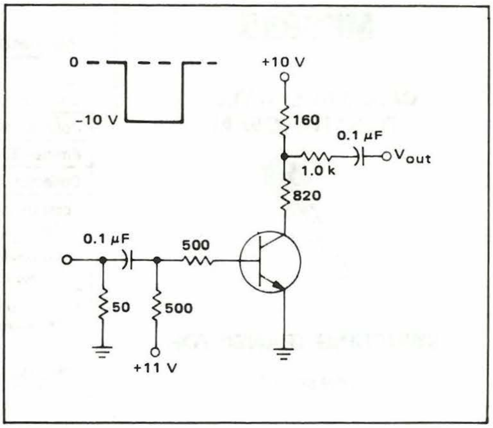


FIGURE 2 – STORAGE TIME TEST CIRCUIT



MPS835

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	25	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)	I_{CBO}	—	—	0.5	µAdc
Collector Cutoff Current ($V_{CE} = 20$ Vdc, $V_{BE} = 0$)	I_{CES}	—	—	10	µAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	20	35	—	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	0.20	0.30	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	—	0.78	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	300	600	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	1.5	4.0	pF
SWITCHING CHARACTERISTICS					
Storage Time (Figure 1) ($V_{CC} = 10$ V, $I_C = 10$ mAdc, $I_{B1} = I_{B2} = 10$ mAdc)	t_s	—	28	35	ns
Turn-On Time (Figure 2) ($V_{CC} = 3.0$ V, $V_{BE(off)} = 2.0$ V, $I_C = 10$ mAdc, $I_{B1} = 3.0$ mAdc, $I_{B2} = 1.0$ mAdc)	t_{on}	—	15	20	ns
Turn-Off Time (Figure 2) ($V_{CC} = 3.0$ V, $I_C = 10$ mAdc, $I_{B1} = 3.0$ mA, $I_{B2} = 1.0$ mAdc)	t_{off}	—	30	35	ns

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

FIGURE 1 — TURN-ON AND TURN-OFF TIME TEST CIRCUIT

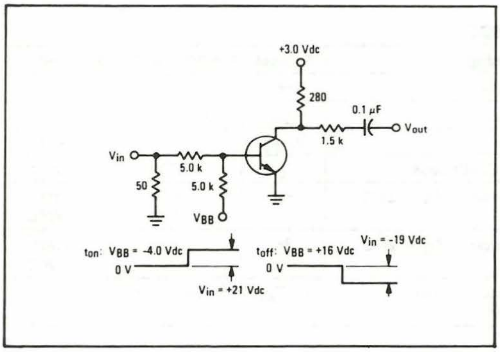
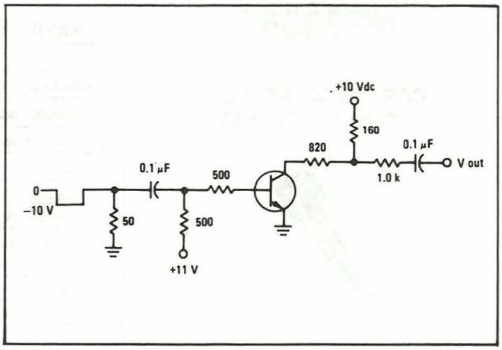


FIGURE 2 — STORAGE TIME TEST CIRCUIT



2

MPS918
MPS3563

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MPS918	MPS3563	Unit
Collector-Emitter Voltage	V_{CEO}	15	12	Vdc
Collector-Base Voltage	V_{CBO}	30	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	2.0	Vdc
Collector Current — Continuous	I_C	50		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 3.0 mAdc, I_B = 0)	MPS918 MPS3563	$V_{(BR)CEO}$	15 12	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0) (I_C = 100 μAdc, I_E = 0)	MPS918 MPS3563	$V_{(BR)CBO}$	30 30	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	MPS918 MPS3563	$V_{(BR)EBO}$	3.0 2.0	— —	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	MPS918 MPS3563	I_{CBO}	— —	10 50	nAdc
ON CHARACTERISTICS					
DC Current Gain(2) (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 8.0 mAdc, V_{CE} = 10 Vdc)	MPS918	h_{FE}	20 20	— 200	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	MPS918	$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	MPS918	$V_{BE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz) (I_C = 8.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	MPS918 MPS3563	f_T	600 600	— 1500	MHz
Output Capacitance (V_{CB} = 0 Vdc, I_E = 0, f = 140 kHz) (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz) (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	MPS918 MPS918 MPS3563	C_{obo}	— — —	3.0 1.7 1.7	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 140 kHz)	MPS918	C_{ibo}	—	2.0	pF
Small-Signal Current Gain (I_C = 8.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS3563	h_{fe}	20	250	—
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, R_S = 400 ohms, f = 60 MHz)	MPS918	NF	—	6.0	dB

2

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (I_C = 6.0 mAdc, V_{CB} = 12 Vdc, f = 200 MHz) (I_C = 8.0 mAdc, V_{CE} = 10 Vdc, f = 200 MHz) ($G_{fd} + G_{re} < -20$ dB)	 MPS918 MPS3563	G_{pe}	 15 14	 — —	dB
Power Output (I_C = 8.0 mAdc, V_{CB} = 15 Vdc, f = 500 MHz)	 MPS918	P_{out}	30	—	mW
Oscillator Collector Efficiency (I_C = 8.0 mAdc, V_{CB} = 15 Vdc, P_{out} = 30 mW, f = 500 MHz)	 MPS918	η	25	—	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

2

MPS929,A
MPS930,A

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MPS929 MPS930	MPS929A MPS930A	Unit
Collector-Emitter Voltage	V_{CEO}	45		Vdc
Collector-Base Voltage	V_{CBO}	45	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	6.0	Vdc
Collector Current — Continuous	I_C	100		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

Refer to MPS3903 for additional graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	45	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	MPS929, MPS930 MPS929A, MPS930A	$V_{(BR)CBO}$	45 60	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	MPS929, MPS930 MPS929A, MPS930A	$V_{(BR)EBO}$	5.0 6.0	— —	Vdc
Collector Cutoff Current ($V_{CE} = 5.0$ Vdc, $I_B = 0$)		I_{CEO}	—	2.0	nAdc
Collector Cutoff Current ($V_{CB} = 45$ Vdc, $I_E = 0$)	MPS929, MPS930 MPS929A, MPS930A	I_{CBO}	— —	10 2.0	nAdc
Collector Cutoff Current ($V_{CE} = 45$ Vdc, $V_{BE} = 0$)	MPS929, MPS930 MPS929A, MPS930A	I_{CES}	— —	10 2.0	nAdc
($V_{CE} = 45$ Vdc, $V_{BE} = 0$, $T_A = 125°C$)	MPS929, MPS930 MPS929A, MPS930A		— —	10 2.0	μAdc
Emitter Cutoff Current ($V_{EB} = 5.0$ Vdc, $I_C = 0$)	MPS929, MPS930 MPS929A, MPS930A	I_{EBO}	— —	10 2.0	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) ($I_C = 1.0$ μAdc, $V_{CE} = 5.0$ Vdc)	MPS929A MPS930A	h_{FE}	25 60	— —	—
($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc)	MPS929, MPS929A MPS930, MPS930A		40 100	120 300	
($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc, $T_A = -55°C$)	MPS929 MPS929A MPS930 MPS930A		10 15 20 30	— — — —	
($I_C = 500$ μAdc, $V_{CE} = 5.0$ Vdc)	MPS929, MPS929A MPS930, MPS930A		60 150	— —	
($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	MPS929, MPS929A MPS930, MPS930A		— —	350 600	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 0.5 mAdc)	MPS929, MPS930 MPS929A, MPS930A	$V_{CE(sat)}$	— —	1.0 0.5	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 0.5 mAdc)	MPS929, MPS930 MPS929A, MPS930A	$V_{BE(sat)}$	0.6 0.7	1.0 0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 30 MHz)	MPS929, MPS930 MPS929A, MPS930A	f_T	30 45	— —	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	MPS929, MPS930 MPS929A, MPS930A	C_{obo}	— —	8.0 6.0	pF
Input Impedance (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ib}	25	32	Ohms
Voltage Feedback Ratio (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{rb}	—	600	$X 10^{-6}$
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	MPS929, MPS929A MPS930, MPS930A	h_{fe}	60 150	350 600	—
Output Admittance (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ob}	—	1.0	μmho
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kohms, f = 10 Hz to 15.7 kHz)	MPS929, MPS929A MPS930, MPS930A	NF	— —	4.0 3.0	dB

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

TYPICAL CHARACTERISTICS

FIGURE 1 — DC CURRENT GAIN

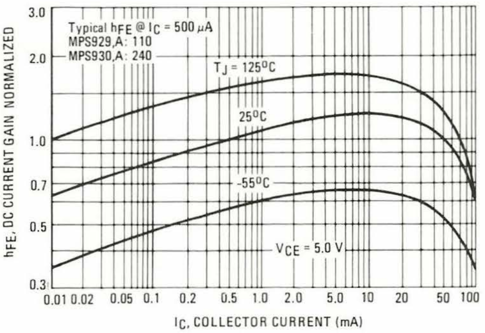
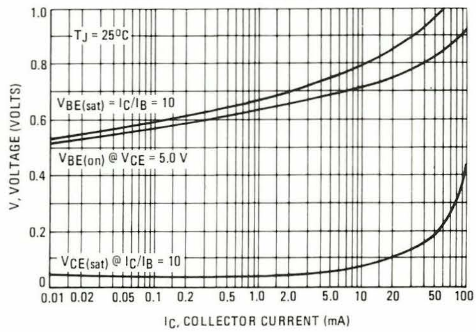


FIGURE 2 — "ON" VOLTAGES



2

FIGURE 3 — COLLECTOR SATURATION REGION

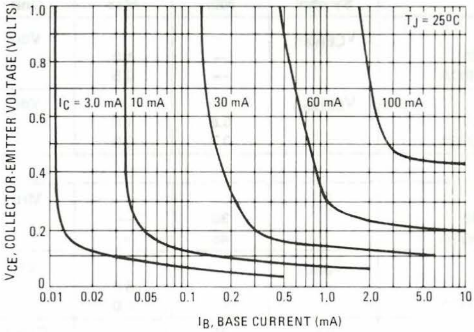


FIGURE 4 — TEMPERATURE COEFFICIENTS

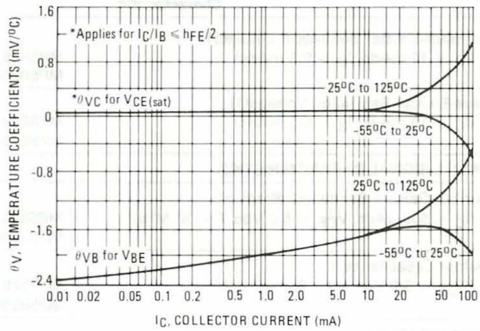


FIGURE 5 — CURRENT-GAIN — BANDWIDTH PRODUCT

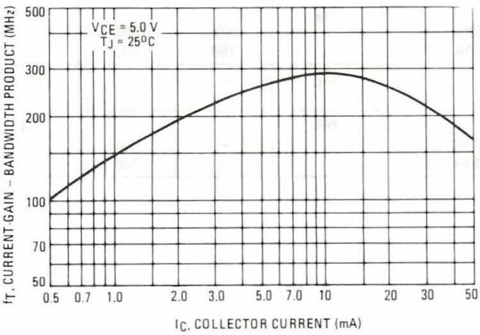
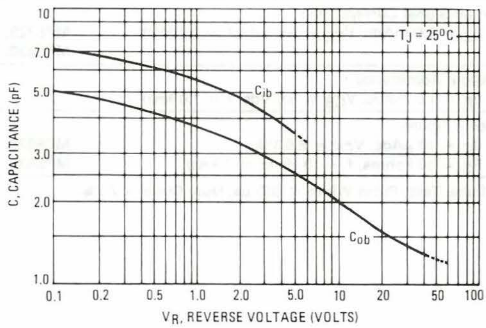


FIGURE 6 — CAPACITANCES



MPS2222
MPS2222A*

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

2

MAXIMUM RATINGS

Rating	Symbol	MPS2222	MPS2222A	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	Vdc
Collector-Base Voltage	V_{CBO}	60	75	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	6.0	Vdc
Collector Current — Continuous	I_C	600		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)	 MPS2222 MPS2222A	$V_{(BR)CEO}$	 30 40	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	 MPS2222 MPS2222A	$V_{(BR)CBO}$	 60 75	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	 MPS2222 MPS2222A	$V_{(BR)EBO}$	 5.0 6.0	 — —	Vdc
Collector Cutoff Current ($V_{CE} = 60$ Vdc, $V_{EB(off)} = 3.0$ Vdc)	 MPS2222A	I_{CEX}	—	10	nAdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$) ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 50$ Vdc, $I_E = 0$, $T_A = 125°C$) ($V_{CB} = 50$ Vdc, $I_E = 0$, $T_A = 125°C$)	 MPS2222 MPS2222A MPS2222 MPS2222A	I_{CBO}	 — — — —	 0.01 0.01 10 10	μAdc
Emitter Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)	 MPS2222A	I_{EBO}	—	10	nAdc
Base Cutoff Current ($V_{CE} = 60$ Vdc, $V_{EB(off)} = 3.0$ Vdc)	 MPS2222A	I_{BL}	—	20	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, $T_A = -55°C$) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)(1) ($I_C = 150$ mAdc, $V_{CE} = 1.0$ Vdc)(1) ($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc)(1)	 MPS2222A only MPS2222 MPS2222A	h_{FE}	 35 50 75 35 100 50 30 40	 — — — — 300 — — —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)	 MPS2222 MPS2222A MPS2222 MPS2222A	$V_{CE(sat)}$	 — — — —	 0.4 0.3 1.6 1.0	Vdc

*Also available as a PN2222,A.

2

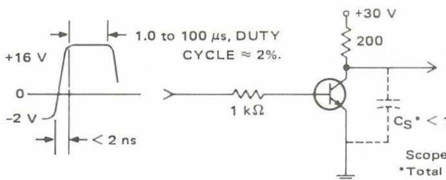
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	 MPS2222 MPS2222A MPS2222 MPS2222A	$V_{BE(sat)}$	 — 0.6 — —	 1.3 1.2 2.6 2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	 MPS2222 MPS2222A	f_T	 250 300	 — —	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	8.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	 MPS2222 MPS2222A	C_{ibo}	 — —	 30 25	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	 MPS2222A MPS2222A	h_{ie}	 2.0 0.25	 8.0 1.25	kΩ
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	 MPS2222A MPS2222A	h_{re}	 — —	 8.0 4.0	$X\ 10^{-4}$
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	 MPS2222A MPS2222A	h_{fe}	 50 75	 300 375	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	 MPS2222A MPS2222A	h_{oe}	 5.0 25	 35 200	μmhos
Collector Base Time Constant (I_E = 20 mAdc, V_{CB} = 20 Vdc, f = 31.8 MHz)	 MPS2222A	$rb'C_c$	—	150	ps
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 kΩ, f = 1.0 kHz)	 MPS2222A	NF	—	4.0	dB
SWITCHING CHARACTERISTICS MPS2222A only					
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figure 1)	t_d	—	10	ns
Rise Time		t_r	—	25	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 2)	t_s	—	225	ns
Fall Time		t_f	—	60	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 – TURN-ON TIME



Scope Rise Time < 4 ns
*Total shunt capacitance of test jig, connectors, and oscilloscope.

FIGURE 2 – TURN-OFF TIME

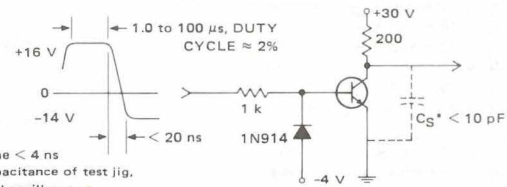


FIGURE 3 — DC CURRENT GAIN

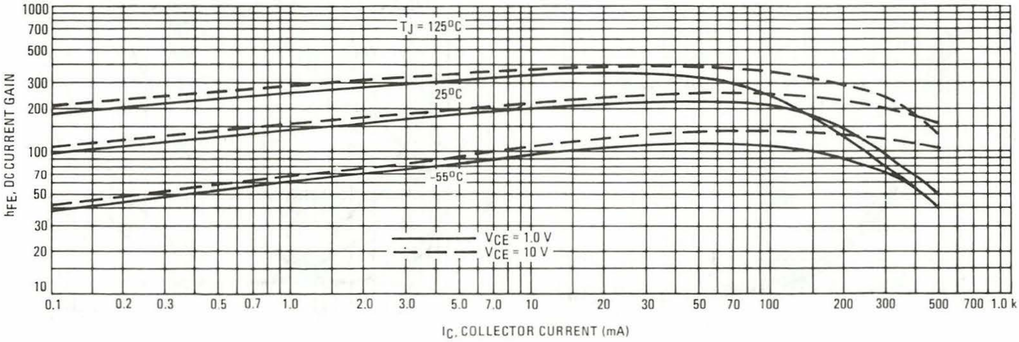


FIGURE 4 — COLLECTOR SATURATION REGION

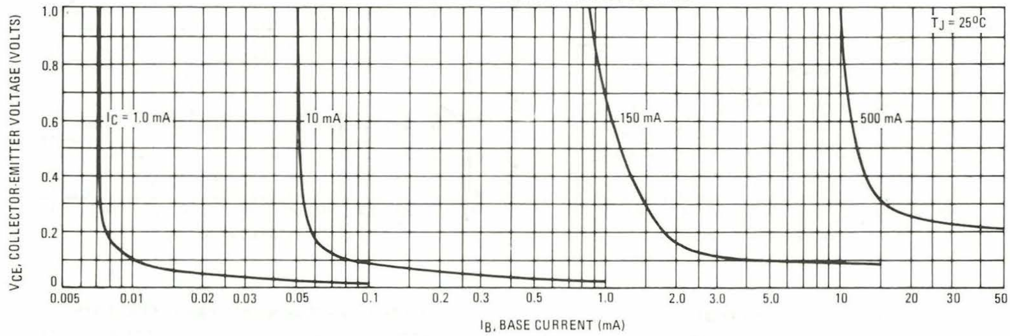


FIGURE 5 — TURN-ON TIME

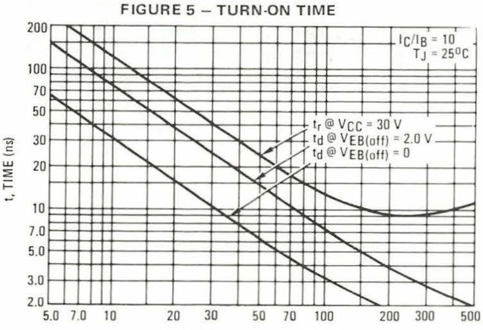
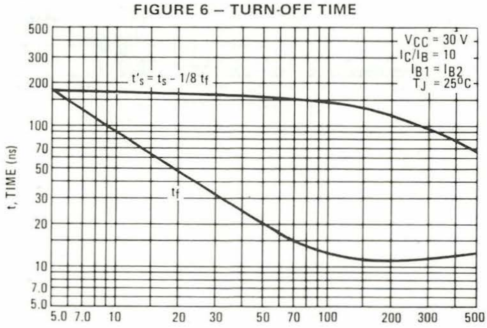


FIGURE 6 — TURN-OFF TIME



2

FIGURE 7 – FREQUENCY EFFECTS

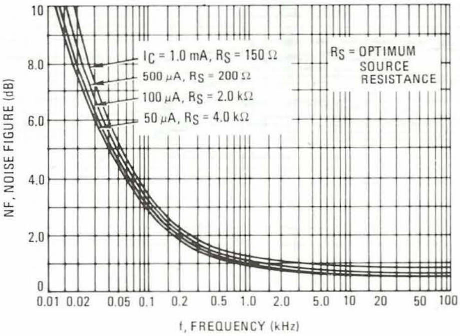


FIGURE 8 – SOURCE RESISTANCE EFFECTS

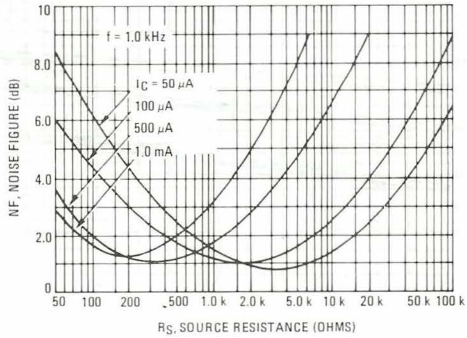


FIGURE 9 – CAPACITANCES

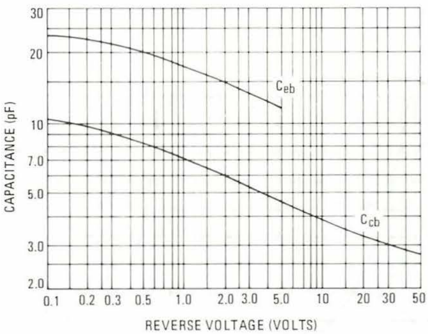


FIGURE 10 – CURRENT-GAIN BANDWIDTH PRODUCT

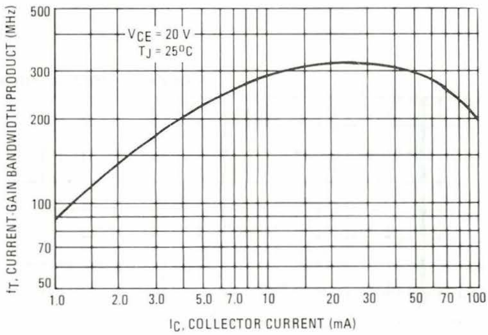


FIGURE 11 – "ON" VOLTAGES

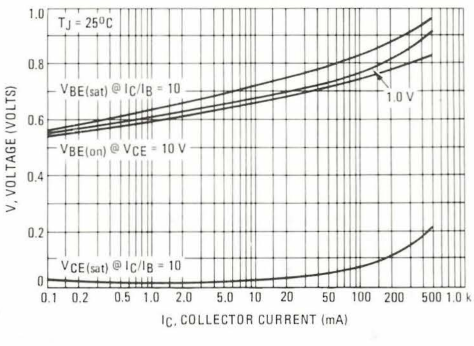
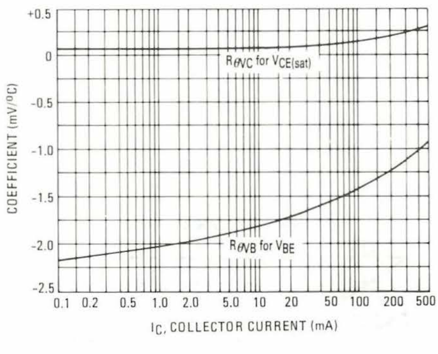


FIGURE 12 – TEMPERATURE COEFFICIENTS



MPS2369

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10$ μAdc, $V_{BE} = 0$)	$V_{(BR)CES}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.5	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$) ($V_{CB} = 20$ Vdc, $I_E = 0$, $T_A = 125°C$)	I_{CBO}	 — —	 — —	 0.4 30	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc, $T_A = -55°C$) ($I_C = 100$ mAdc, $V_{CE} = 2.0$ Vdc)	h_{FE}	 40 20 20	 — — —	 120 — —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	—	0.25	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	0.70	—	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	—	4.0	pF
Small-Signal Current Gain ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	h_{fe}	5.0	—	—	—
SWITCHING CHARACTERISTICS					
Storage Time ($I_{B1} = I_{B2} = I_C = 10$ mAdc) (Figure 3)	t_s	—	5.0	13	ns
Turn-On Time ($V_{CC} = 3.0$ Vdc, $I_C = 10$ mAdc, $I_{B1} = 3.0$ mAdc) (Figure 1)	t_{on}	—	8.0	12	ns
Turn-Off Time ($V_{CC} = 3.0$ Vdc, $I_C = 10$ mAdc, $I_{B1} = 3.0$ mAdc, $I_{B2} = 1.5$ mAdc) (Figure 2)	t_{off}	—	10	18	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

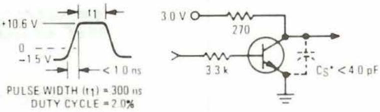
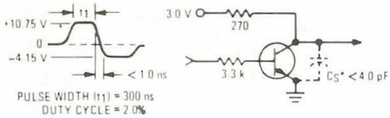


FIGURE 1 — t_{on} CIRCUIT

FIGURE 2 — t_{off} CIRCUIT



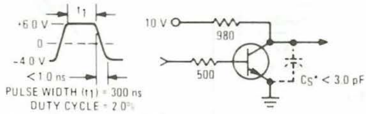


FIGURE 3 — STORAGE TEST CIRCUIT

*Total shunt capacitance of test jig and connectors.

MPS2714

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

SWITCHING TRANSISTOR

NPN SILICON

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	18	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_E = 0$)	$V_{(BR)CEO}$	18	—	—	V
Collector Cutoff Current ($V_{CB} = 18.0$ Vdc, $I_E = 0$)	I_{CBO}	—	—	0.5	μA
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	0.5	μA
ON CHARACTERISTICS					
DC Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 4.5$ Vdc)	h_{FE}	75	—	225	—
Collector-Emitter Saturation Voltage ($I_C = 50$ mAdc, $I_B = 3.0$ mAdc)	$V_{CE(sat)}$	—	—	0.3	Vdc
Base-Emitter Saturation Voltage ($I_C = 50$ mAdc, $I_B = 3.0$ mAdc)	$V_{BE(sat)}$	—	—	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	—	250	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	2.5	—	pF
Input Impedance ($I_C = 0.5$ mAdc, $V_{CE} = 1.0$ Vdc, f = 1.0 kHz)	h_{ie}	—	3000	—	ohms
Small-Signal Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 4.5$ Vdc, f = 1.0 kHz)	h_{fe}	80	—	300	—
SWITCHING CHARACTERISTICS					
Delay Time ($I_C = 10$ mA, $I_{B1} = 3.0$ mA, $V_{CC} = 10$ V)	t_d	—	7.0	—	ns
Rise Time ($I_C = 10$ mA, $I_{B1} = 3.0$ mA, $V_{CC} = 10$ V)	t_r	—	6.0	—	ns
Storage Time ($I_C = 10$ mA, $I_{B1} = 3.0$ mA, $I_{B2} = 1.0$ mA, $V_{CC} = 10$ V)	t_s	—	12	—	ns
Fall Time ($I_C = 10$ mA, $I_{B1} = 3.0$ mA, $I_{B2} = 1.0$ mA, $V_{CC} = 10$ V)	t_f	—	9.0	—	ns

2

MPS2907
MPS2907A

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MPS2907	MPS2907A	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	 MPS2907 MPS2907A	$V_{(BR)CEO}$	 40 60	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)		$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 30$ Vdc, $V_{BE(off)} = 0.5$ Vdc)		I_{CEX}	—	50	nAdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$)	 MPS2907 MPS2907A	I_{CBO}	 — —	 0.020 0.010	μAdc
($V_{CB} = 50$ Vdc, $I_E = 0$, $T_A = 125°C$)	MPS2907 MPS2907A		— —	20 10	
Base Current ($V_{CE} = 30$ Vdc, $V_{BE(off)} = 0.5$ Vdc)		I_B	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 10$ Vdc)	 MPS2907 MPS2907A	h_{FE}	 35 75	 — —	—
($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc)	MPS2907 MPS2907A		50 100	— —	
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	MPS2907 MPS2907A		75 100	— —	
($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)(1)	MPS2907, MPS2907A		100	300	
($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc)(1)	MPS2907 MPS2907A		30 50	— —	
Collector-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)		$V_{CE(sat)}$	 — —	 0.4 1.6	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)		$V_{BE(sat)}$	 — —	 1.3 2.6	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1),(2) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	30	pF
SWITCHING CHARACTERISTICS					
Turn-On Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figures 1 and 5)	t_{on}	—	45	ns
Delay Time		t_d	—	10	ns
Rise Time		t_r	—	40	ns
Turn-Off Time	(V_{CC} = 6.0 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 2)	t_{off}	—	100	ns
Storage Time		t_s	—	80	ns
Fall Time		t_f	—	30	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 — DELAY AND RISE TIME TEST CIRCUIT

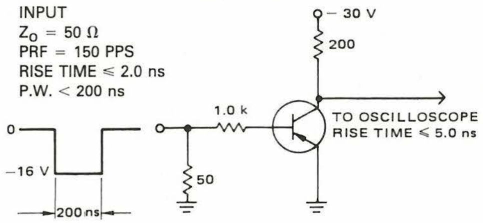
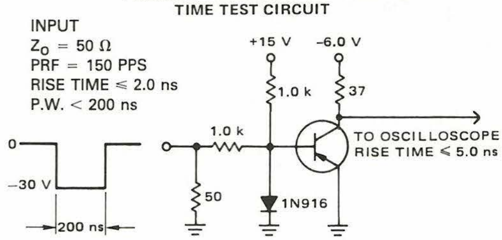
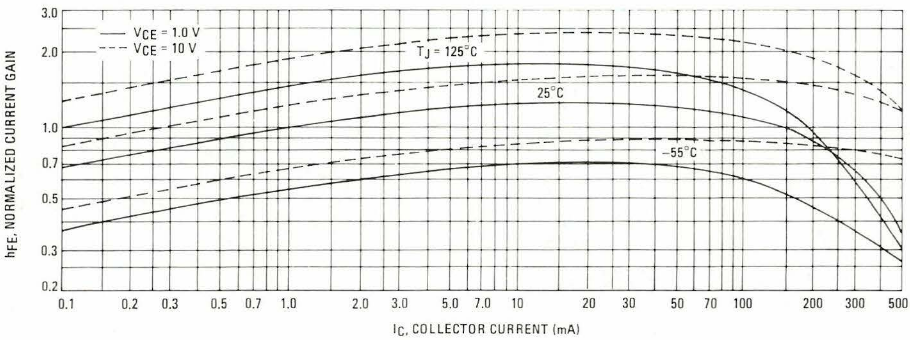


FIGURE 2 — STORAGE AND FALL TIME TEST CIRCUIT



TYPICAL CHARACTERISTICS

FIGURE 3 — DC CURRENT GAIN



2

FIGURE 4 – COLLECTOR SATURATION REGION

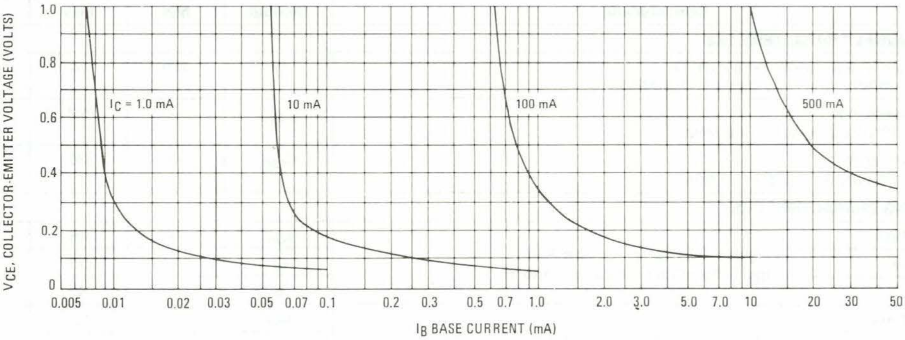


FIGURE 5 – TURN-ON TIME

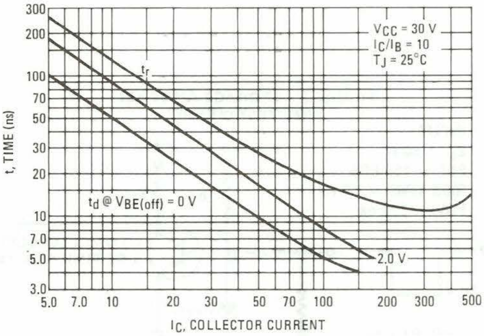
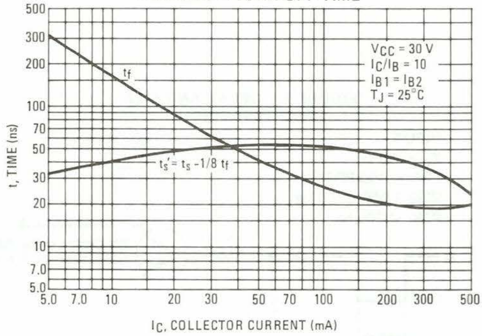


FIGURE 6 – TURN-OFF TIME



TYPICAL SMALL-SIGNAL CHARACTERISTICS
NOISE FIGURE
V_{CE} = 10 Vdc, T_A = 25°C

FIGURE 7 – FREQUENCY EFFECTS

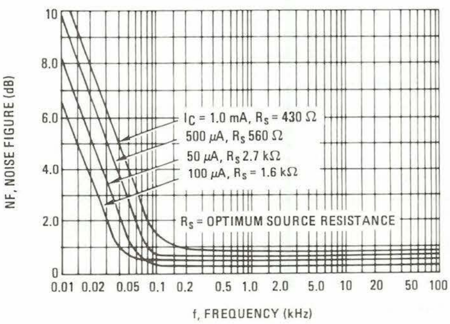


FIGURE 8 – SOURCE RESISTANCE EFFECTS

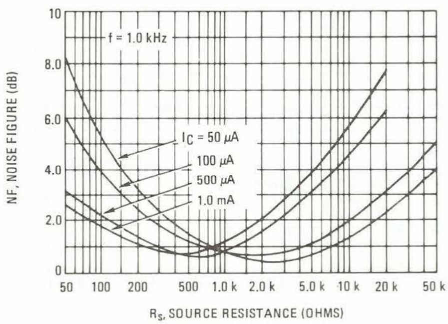


FIGURE 9 — CAPACITANCES

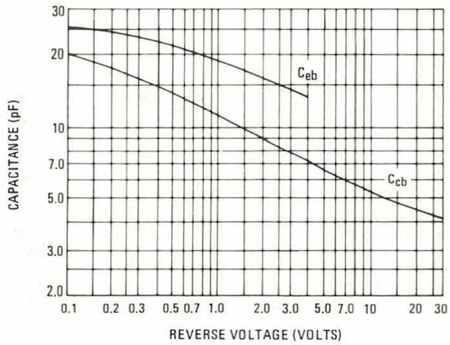


FIGURE 10 — CURRENT-GAIN — BANDWIDTH PRODUCT

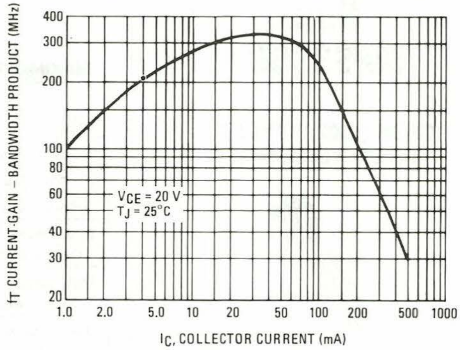


FIGURE 11 — "ON" VOLTAGE

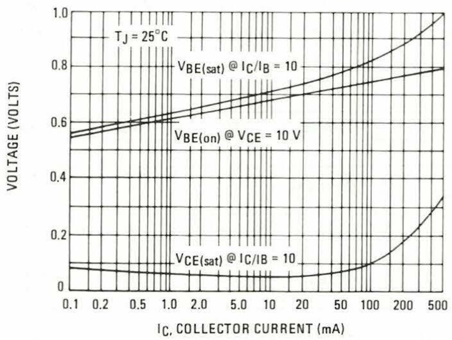
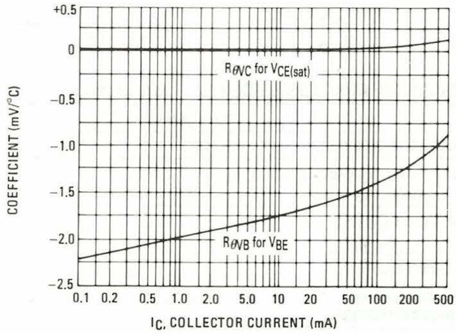


FIGURE 12 — TEMPERATURE COEFFICIENTS



2

MPS3390 thru MPS3398

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N3903 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	25	—	V
Collector Cutoff Current ($V_{CB} = 18$ Vdc, $I_E = 0$)		I_{CBO}	—	0.1	μA
Emitter Cutoff Current ($V_{EB} = 5.0$ Vdc, $I_C = 0$)		I_{EBO}	—	0.1	μA
ON CHARACTERISTICS					
DC Current Gain ($V_{CE} = 4.5$ Vdc, $I_C = 2.0$ mAdc)	MPS3390 MPS3391 MPS3392 MPS3393 MPS3394 MPS3395 MPS3396 MPS3397 MPS3398	h_{FE}	400 250 150 90 55 150 90 55 55	800 500 300 180 110 500 500 500 800	—
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance ($V_{CB} = 10$ V, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	10	pF
Small-Signal Current Gain ($V_{CE} = 4.5$ V, $I_C = 2.0$ mA, f = 1.0 kHz)	MPS3390 MPS3391 MPS3392 MPS3393 MPS3394 MPS3395 MPS3396 MPS3397 MPS3398	h_{fe}	400 250 150 90 55 150 90 55 55	1250 800 500 400 300 800 800 800 1250	—

MPS3391A

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	25	—	Vdc
Collector Cutoff Current	I_{CBO}			μAdc
($V_{CB} = 25$ Vdc, $I_E = 0$)		—	0.1	
($V_{CB} = 25$ Vdc, $I_E = 0$, $T_A = 100°C$)		—	10	
Emitter Cutoff Current ($V_{EB} = 5.0$ Vdc, $I_C = 0$)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 4.5$ Vdc)	h_{FE}	250	500	—
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	10	pF
Current Gain — High Frequency ($I_C = 100$ μAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	$\|h_{fe}\|$	170	—	—
Noise Figure ($I_C = 100$ μAdc, $V_{CE} = 4.5$ Vdc, $R_g = 5.0$ kohms, f = 10 Hz to 15.7 kHz)	NF	—	5.0	dB

2

MPS3402
MPS3403

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

TRANSISTOR

NPN SILICON

Refer to MPS8098 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	500	mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mA)		$V_{(BR)CEO}$	25	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μA)		$V_{(BR)CBO}$	25	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μA)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 18$ V) ($V_{CB} = 18$ V, $T_A = 100°C$)		I_{CBO}	 — —	 100 15	 nA μA
Emitter Cutoff Current ($V_{BE} = 5.0$ V)		I_{EBO}	—	100	nA
ON CHARACTERISTICS					
DC Current Gain ($I_C = 2.0$ mA, $V_{CE} = 4.5$ V) ($I_C = 2.0$ mA, $V_{CE} = 4.5$ V)	 MPS3402 MPS3403	h_{FE}	 75 180	 225 540	—
Collector-Emitter Saturation Voltage ($I_C = 50$ mA, $I_B = 3.0$ mA)		$V_{CE(sat)}$	—	0.3	Vdc
Base-Emitter Saturation Voltage ($I_C = 50$ mA, $I_B = 3.0$ mA)		$V_{BE(sat)}$	0.6	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Small-Signal Current Gain ($I_C = 2.0$ mA, $V_{CE} = 4.5$ V, f = 1.0 kHz) ($I_C = 2.0$ mA, $V_{CE} = 4.5$ V, f = 1.0 kHz)		h_{fe}	 75 180	 — —	—

MPS3404
MPS3405

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

TRANSISTOR

NPN SILICON

Refer to MPS8098 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CBO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	500	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mA)		$V_{(BR)CEO}$	50	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μA)		$V_{(BR)CBO}$	50	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μA)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 18 V) (V_{CB} = 18 V, T_A = 100°C)		I_{CBO}	 — —	 100 15	 nA μA
Emitter Cutoff Current (V_{BE} = 5.0 V)		I_{EBO}	—	100	nA
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 mA, V_{CE} = 4.5 V) (I_C = 2.0 mA, V_{CE} = 4.5 V)	 MPS3404 MPS3405	h_{FE}	 75 180	 225 540	—
Collector-Emitter Saturation Voltage (I_C = 50 mA, I_B = 3.0 mA)		$V_{CE(sat)}$	—	0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mA, I_B = 3.0 mA)		$V_{BE(sat)}$	0.6	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Small-Signal Current Gain (I_C = 2.0 mA, V_{CE} = 4.5 V, f = 1.0 kHz) (I_C = 2.0 mA, V_{CE} = 4.5 V, f = 1.0 kHz)	 MPS3404 MPS3405	h_{fe}	 75 100	 — —	—

MPS3563

For Specifications, See MPS918

2

MPS3565

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N4400 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Power Dissipation @ T_A = 60°C	P_D	450	mW
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Base Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CBO}$	30	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 2.0 mA)	$V_{(BR)CEO(sus)}$	25	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μA)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CB} = 25 V) (V_{CB} = 25 V, T_A = 65°C)	I_{CBO}	 — —	 50 3.0	 nAdc μA
ON CHARACTERISTICS				
DC Current Gain (I_C = 100 μA, V_{CE} = 10 V) (I_C = 1.0 mA, V_{CE} = 10 V)	h_{FE}	 70 150	 — 600	—
Collector-Emitter Saturation Voltage (I_C = 1.0 mA, I_B = 0.1 mA)	$V_{CE(sat)}$	—	0.35	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 10 V, f = 1.0 MHz)	C_{obo}	—	4.0	pF
Small-Signal Current Gain (I_C = 1.0 mA, V_{CE} = 5.0 V, f = 20 MHz) (I_C = 10 mA, V_{CE} = 5.0 V, f = 1.0 kHz)	h_{fe}	 2.0 120	 12 750	—

MPS3566

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N4400 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Power Dissipation @ $T_A = 60°C$	P_D	450	mW
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 30$ mA)	$V_{(BR)CEO(sus)}$	30	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu A$)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu A$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 20$ V) ($V_{CB} = 20$ V, $T_A = 75°C$)	I_{CBO}	 — —	 50 5.0	 nA μA
Emitter Cutoff Current ($V_{BE} = 5.0$ V)	I_{EBO}	—	10	μA
ON CHARACTERISTICS				
DC Current Gain ($I_C = 10$ mA, $V_{CE} = 10$ V) ($I_C = 2.0$ mA, $V_{CE} = 10$ V)	h_{FE}	 150 80	 600 —	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mA, $I_B = 10$ mA)	$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter On Voltage(1) ($I_C = 100$ mA, $V_{CE} = 1.0$ V)	$V_{BE(on)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 10$ V, f = 1.0 MHz)	C_{obo}	—	25	pF
Small-Signal Current Gain ($I_C = 30$ mA, $V_{CE} = 10$ V, f = 20 MHz)	h_{fe}	2.0	35	—

(1) Pulse Test: Pulse Width $\leq 300\ \mu s$, Duty Cycle $\leq 2.0\%$.

MPS3567
MPS3568
MPS3569

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N4400 for graphs for MPS3567, 3569.*

MAXIMUM RATINGS

Rating	Symbol	MPS3567 MPS3569	MPS3568	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	80		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) ($I_C = 30$ mAdc, $I_B = 0$)	 MPS3567, MPS3569 MPS3568	$V_{CEO(sus)}$	 40 60	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)		$V_{(BR)CBO}$	80	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 40$ Vdc, $I_E = 0$) ($V_{CB} = 40$ Vdc, $I_E = 0$, $T_A = 75°C$)		I_{CBO}	 — —	 50 5.0	 nAdc μAdc
Emitter Cutoff Current ($V_{EB} = 4.0$ Vdc, $I_C = 0$)		I_{EBO}	—	25	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 30$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 1.0$ Vdc)	 MPS3567, MPS3568 MPS3569 MPS3567, MPS3568 MPS3569	h_{FE}	 40 100 40 100	 — — 120 300	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)		$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)		$V_{BE(sat)}$	—	1.1	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)		f_T	60	—	MHz
Output Capacitance ($V_{CB} = 10$ V, f = 1.0 MHz)		C_{obo}	—	20	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)		C_{ibo}	—	80	pF

*Refer to MPS8098 for graphs for MPS3568.
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPS3638
MPS3638A

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

SWITCHING TRANSISTOR

PNP SILICON

Refer to 2N4402 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Emitter Voltage	V_{CES}	25	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	40	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu Adc$, $V_{BE} = 0$)		$V_{(BR)CES}$	25	—	Vdc
Collector-Emitter Sustaining Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)		$V_{CEO(sus)}$	25	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu Adc$, $I_E = 0$)		$V_{(BR)CBO}$	25	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu Adc$, $I_C = 0$)		$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 15$ Vdc, $V_{BE} = 0$) ($V_{CE} = 15$ Vdc, $V_{BE} = 0$, $T_A = -65°C$)		I_{CES}	 — —	 0.035 2.0	μAdc
Emitter Cutoff Current ($V_{EB} = 3.0$ V, $I_C = 0$)		I_{EBO}	—	35	nA
Base Current ($V_{CE} = 15$ Vdc, $V_{BE} = 0$)		I_B	—	0.035	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc)	 MPS3638A	h_{FE}	 80	 —	—
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	MPS3638 MPS3638A		20 100	— —	
($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc)	MPS3638 MPS3638A		30 100	— —	
($I_C = 300$ mAdc, $V_{CE} = 2.0$ Vdc)	MPS3638 MPS3638A		20 20	— —	
Collector-Emitter Saturation Voltage ($I_C = 50$ mAdc, $I_B = 2.5$ mAdc) ($I_C = 300$ mAdc, $I_B = 30$ mAdc)		$V_{CE(sat)}$	 — —	 0.25 1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 50$ mAdc, $I_B = 2.5$ mAdc) ($I_C = 300$ mAdc, $I_B = 30$ mAdc)		$V_{BE(sat)}$	 — 0.80	 1.1 2.0	Vdc

2

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (V_{CE} = 3.0 Vdc, I_C = 50 mAdc, f = 100 MHz)	MPS3638 MPS3638A	f_T	100 150	— —	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	MPS3638 MPS3638A	C_{obo}	— —	20 10	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	MPS3638 MPS3638A	C_{ibo}	— —	65 25	pF
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{ie}	—	2000	Ohms
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS3638 MPS3638A	h_{re}	— —	26 15	X 10^{-4}
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS3638 MPS3638A	h_{fe}	25 100	— —	—
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	—	1.2	mmhos
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 10 Vdc, I_C = 300 mAdc, I_{B1} = 30 mAdc)	t_d	—	20	ns
Rise Time		t_r	—	70	ns
Storage Time	(V_{CC} = 10 Vdc, I_C = 300 mAdc, I_{B1} = 30 mAdc, I_{B2} = 30 mAdc)	t_s	—	140	ns
Fall Time		t_f	—	70	ns
Turn-On Time	(I_C = 300 mAdc, I_{B1} = 30 mAdc)	t_{on}	—	75	ns
Turn-Off Time	(I_C = 300 mAdc, I_{B1} = 30 mAdc, I_{B2} = 30 mAdc)	t_{off}	—	170	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPS3640

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

SWITCHING TRANSISTOR

PNP SILICON

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	12	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	80	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

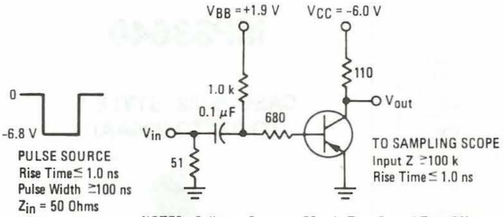
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu Adc$, $V_{BE} = 0$)	$V_{(BR)CES}$	12	—	Vdc
Collector-Emitter Sustaining Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{CEO(sus)}$	12	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu Adc$, $I_E = 0$)	$V_{(BR)CBO}$	12	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu Adc$, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 6.0$ Vdc, $V_{BE} = 0$) ($V_{CE} = 6.0$ Vdc, $V_{BE} = 0$, $T_A = 65°C$)	I_{CES}	— —	0.01 1.0	μAdc
Base Current ($V_{CE} = 6.0$ Vdc, $V_{BE} = 0$)	I_B	—	10	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 0.3$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	30 20	120 —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc, $T_A = 65°C$)	$V_{CE(sat)}$	— — —	0.2 0.6 0.25	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 0.5$ mAdc) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{BE(sat)}$	0.75 0.8 —	0.95 1.0 1.5	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)	f_T	500	—	MHz
Output Capacitance ($V_{CB} = = 5.0$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	3.5	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)	C_{ibo}	—	3.5	pF
SWITCHING CHARACTERISTICS				
Delay Time ($V_{CC} = 6.0$ Vdc, $I_C = 50$ mAdc, $V_{BE(off)} = 1.9$ Vdc, $I_{B1} = 5.0$ mAdc)	t_d	—	10	ns
Rise Time ($V_{CC} = 6.0$ Vdc, $I_C = 50$ mAdc, $V_{BE(off)} = 1.9$ Vdc, $I_{B1} = 5.0$ mAdc)	t_r	—	30	ns
Storage Time ($V_{CC} = 6.0$ Vdc, $I_C = 50$ mAdc, $I_{B1} = I_{B2} = 5.0$ mAdc)	t_s	—	20	ns
Fall Time ($V_{CC} = 6.0$ Vdc, $I_C = 50$ mAdc, $I_{B1} = I_{B2} = 5.0$ mAdc)	t_f	—	12	ns
Turn-On Time ($V_{CC} = 6.0$ Vdc, $I_C = 50$ mAdc, $V_{BE(off)} = 1.9$ Vdc, $I_{B1} = 5.0$ mAdc) ($V_{CC} = 1.5$ Vdc, $I_C = 10$ mAdc, $I_{B1} = 0.5$ mAdc)	t_{on}	— —	25 60	ns
Turn-Off Time ($V_{CC} = 6.0$ Vdc, $I_C = 50$ mAdc, $V_{BE(off)} = 1.9$ V, $I_{B1} = I_{B2} = 5.0$ mAdc) ($V_{CC} = 1.5$ Vdc, $I_C = 10$ mAdc, $I_{B1} = I_{B2} = 0.5$ mAdc)	t_{off}	— —	35 75	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

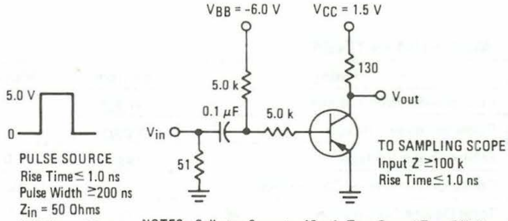
2

FIGURE 1



NOTES: Collector Current = 50 mA, Turn-On and Turn-Off Time Base Currents = 5.0 mA.

FIGURE 2



NOTES: Collector Current = 10 mA, Turn-On and Turn-Off Time Base Currents = 0.5 mA.

FIGURE 3 – DC CURRENT GAIN

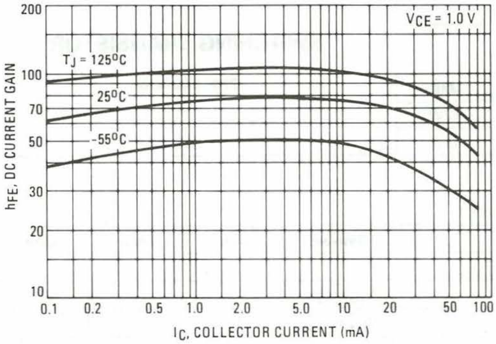


FIGURE 4 – "ON" VOLTAGES

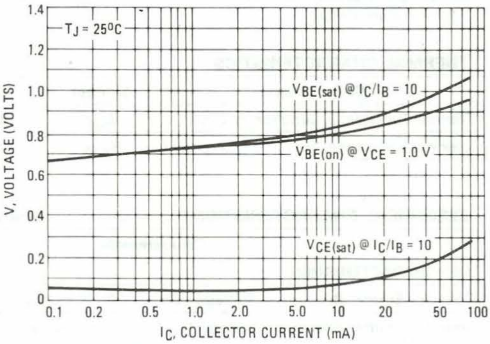


FIGURE 5 – COLLECTOR SATURATION REGION

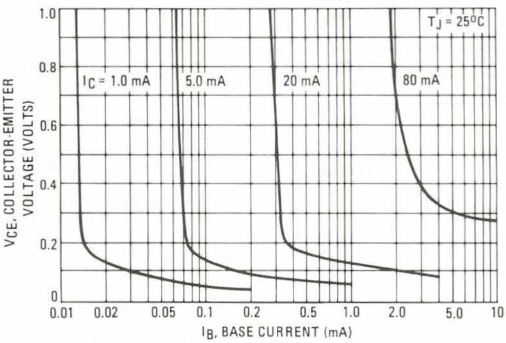


FIGURE 6 – TEMPERATURE COEFFICIENTS

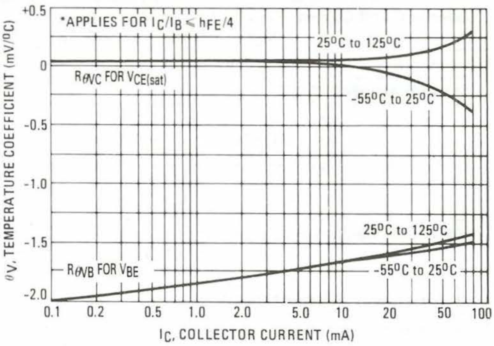


FIGURE 7 – CURRENT-GAIN–BANDWIDTH PRODUCT

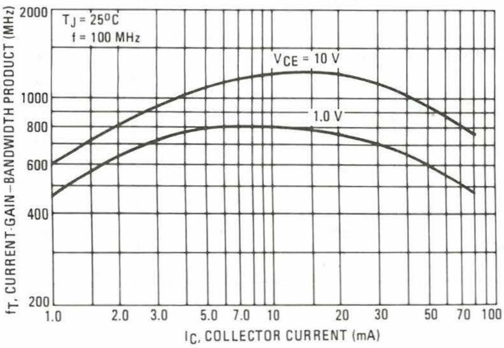
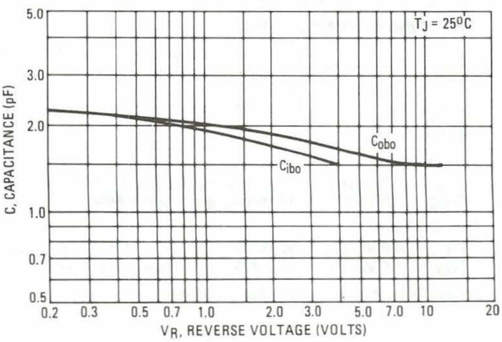


FIGURE 8 – CAPACITANCE



MPS3644
MPS3645

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage MPS3644 MPS3645	V_{CEO}	45 60	Vdc
Collector-Base Voltage MPS3644 MPS3645	V_{CBO}	45 60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	.625	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mA) MPS3644 MPS3645	$V_{CEO(sus)}$	45 60	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μA) MPS3644 MPS3645	$V_{(BR)CBO}$	45 60	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μA)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc) MPS3644 (V_{CE} = 50 Vdc) MPS3645 (V_{CE} = 30 Vdc, @ T_A = 65°C) MPS3644 (V_{CE} = 50 Vdc, @ T_A = 65°C) MPS3645	I_{CES}	 — — — —	 35 35 2.0 2.0	 nA μA
ON CHARACTERISTICS				
DC Current Gain (I_C = 100 μA, V_{CE} = 10 Vdc) (I_C = 1.0 mA, V_{CE} = 10 Vdc) (I_C = 10 mA, V_{CE} = 10 Vdc)(1) (I_C = 50 mA, V_{CE} = 1.0 Vdc)(1) (I_C = 150 mA, V_{CE} = 10 Vdc)(1) (I_C = 300 mA, V_{CE} = 2.0 Vdc)(1)	h_{FE}	40 80 100 115 100 20	— — — 300 300 —	—
Collector-Emitter Saturation Voltage (I_C = 50 mA, I_B = 2.5 mA)(1) (I_C = 150 mA, I_B = 15 mA)(1) (I_C = 300 mA, I_B = 30 mA)(1)	$V_{CE(sat)}$	— — —	0.25 0.4 1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mA, I_B = 2.5 mA)(1) (I_C = 150 mA, I_B = 15 mA)(1) (I_C = 300 mA, I_B = 30 mA)(1)	$V_{BE(sat)}$	— — —	1.0 1.3 2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 10 Vdc)	C_{obo}	—	8.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc)	C_{ibo}	—	25	pF
Input Impedance (I_C = 10 mA, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	—	2000	Ω
Voltage Feedback Ratio (I_C = 10 mA, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{re}	—	1500	$X10^{-6}$
Small-Signal Current Gain (I_C = 20 mA, V_{CE} = 20 Vdc, f = 100 MHz) (I_C = 10 mA, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	2.0 100	— —	—
Output Admittance (I_C = 10 mA, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	—	1200	μmhos
SWITCHING CHARACTERISTICS (FIGURE 1)				
Turn-On Time (I_C = 300 mA, I_{B1} = 30 mA)	t_{on}	—	40	ns
Turn-Off Time (I_C = 300 mA, I_{B1} = I_{B2} = 30 mA)	t_{off}	—	100	ns

(1) Pulse Width = 300 μsec., Duty Cycle = 1.0%.

MPS3646

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

SWITCHING TRANSISTOR

NPN SILICON

Refer to 2N4264 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous — 10 μs Pulse	I_C	300 500	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12.0	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu$Adc, $V_{BE} = 0$)	$V_{(BR)CES}$	40	—	Vdc
Collector-Emitter Sustaining Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{CEO(sus)}$	15	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 20$ Vdc, $V_{BE} = 0$) ($V_{CE} = 20$ Vdc, $V_{BE} = 0$, $T_A = 65°C$)	I_{CES}	— —	0.5 3.0	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain ($I_C = 30$ mAdc, $V_{CE} = 0.4$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 0.5$ Vdc) ($I_C = 300$ mA, $V_{CE} = 1.0$ Vdc)	h_{FE}	30 25 15	120 — —	—
Collector-Emitter Saturation Voltage ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc) ($I_C = 100$ mAdc, $I_B = 10$ mAdc) ($I_C = 300$ mAdc, $I_B = 30$ mAdc) ($I_C = 30$ mA, $I_B = 3.0$ mA, $T_A = 65°C$)	$V_{CE(sat)}$	— — — —	0.2 0.28 0.5 0.3	Vdc
Base-Emitter Saturation Voltage ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc) ($I_C = 100$ mAdc, $I_B = 10$ mAdc) ($I_C = 300$ mAdc, $I_B = 30$ mA)	$V_{BE(sat)}$	0.73 — —	0.95 1.2 1.7	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	350	—	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	5.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)	C_{ibo}	—	—	pF

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
Turn-On Time	($V_{CC} = 10$ Vdc, $V_{BE(off)} = 3.0$ Vdc, $I_C = 300$ mAdc, $I_{B1} = 30$ mAdc) (Figure 1)	t_{on}	—	18	ns
Delay Time		t_d	—	10	ns
Rise Time		t_r	—	15	ns
Turn-Off Time	($V_{CC} = 10$ Vdc, $I_C = 300$ mAdc, $I_{B1} = I_{B2} = 30$ mAdc) (Figure 1)	t_{off}	—	28	ns
Fall Time		t_f	—	15	ns
Storage Time ($V_{CC} = 10$ Vdc, $I_C = 10$ mAdc, $I_{B1} = I_{B2} = 10$ mAdc) (Figure 2)		t_s	—	18	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — SWITCHING TIME TEST CIRCUIT

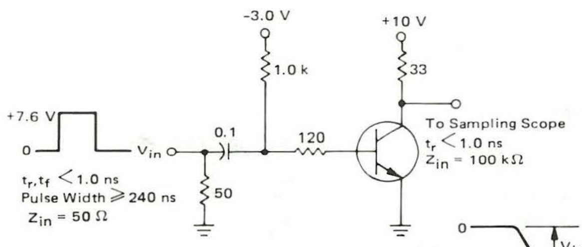
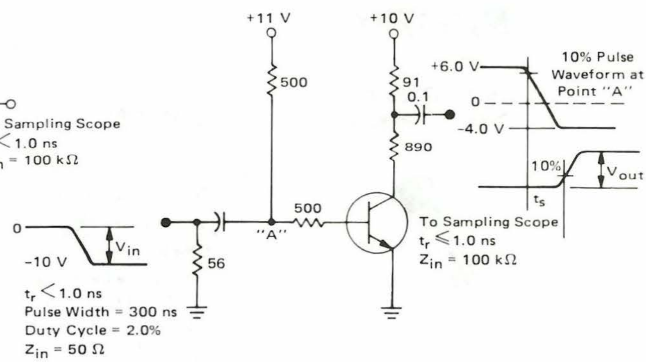


FIGURE 2 — CHARGE STORAGE TIME TEST CIRCUIT



MPS3702
MPS3703

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N4402 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPS3702	MPS3703	Unit
Collector-Emitter Voltage	V_{CEO}	25	30	Vdc
Collector-Base Voltage	V_{CBO}	40	50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.2	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	 MPS3702 MPS3703	$V_{(BR)CEO}$	 25 30	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 MPS3702 MPS3703	$V_{(BR)CBO}$	 40 50	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	 MPS3702 MPS3703	h_{FE}	 60 30	 300 150	—
Collector-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter On Voltage(1) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	0.6	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	100	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, f = 1.0 MHz)		C_{obo}	—	12	pF

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

MPS3704
thru
MPS3706

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N4400 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPS3704 MPS3705	MPS3706	Unit
Collector-Emitter Voltage	V_{CEO}	30	20	Vdc
Collector-Base Voltage	V_{CBO}	50	40	Vdc
Emitter-Base Voltage	V_{EBO}	5		Vdc
Collector Current — Continuous	I_C	600		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.2	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_E = 0)	 MPS3704 MPS3705 MPS3706	$V_{(BR)CEO}$	 30 30 20	 — — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 MPS3704 MPS3705 MPS3706	$V_{(BR)CBO}$	 50 50 40	 — — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 50 mAdc, V_{CE} = 2.0 Vdc)	 MPS3704 MPS3705 MPS3706	h_{FE}	 100 50 30	 300 150 600	—
Collector-Emitter Saturation Voltage(1) (I_C = 100 mAdc, I_B = 5.0 mAdc)	 MPS3704 MPS3705 MPS3706	$V_{CE(sat)}$	 — — —	 0.6 0.8 1.0	Vdc
Base-Emitter On Voltage(1) (I_C = 100 mAdc, V_{CE} = 2.0 Vdc)		$V_{BE(on)}$	0.5	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 2.0 Vdc, f = 20 MHz)		f_T	100	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	12	pF

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

2

MPS3707
MPS3710
MPS3711

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to MPS3903 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current	I_C	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	30	–	V
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}		100	nA
Emitter Cutoff Current (V_{BE} = 6.0 Vdc, I_C = 0)		I_{EBO}		100	nA
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	 MPS3707 MPS3710 MPS3711	h_{FE}	 100 90 180	 400 330 660	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)		$V_{CE(sat)}$	—	1.0	V
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	0.5	1.0	V
SMALL-SIGNAL CHARACTERISTICS					
Small-Signal Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, f = 1.0 KHz) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 KHz)	 MPS3707 MPS3710 MPS3711	h_{fe}	 100 90 180	 550 450 800	—
Noise Figure(1) (V_{CE} = 5.0 V, I_C = 100 μA) (R_G = 5.0 KΩ, Noise Bandwidth = 15.7 KHz)	 MPS3707	NF	 —	 5.0	dB

(1) Average Noise Figure is measured in an amplifier with low frequency response down 3 dB at 10 c/s.

MPS3866

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	55	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	0.4	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

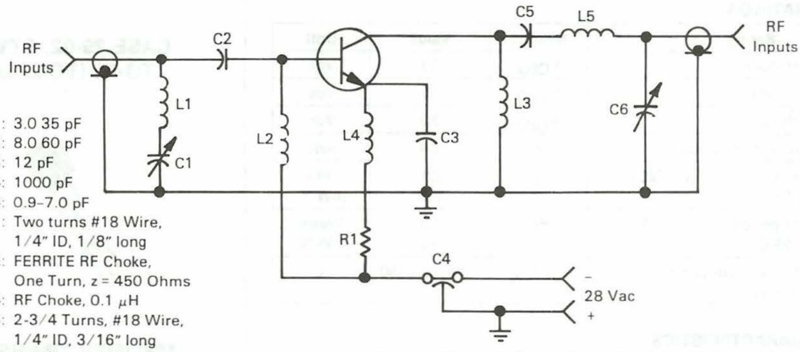
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 5.0$ mAdc, $R_{BE} = 10\ \Omega$)	$V_{CER(sus)}$	55	—	Vdc
Collector-Emitter Sustaining Voltage ($I_C = 5.0$ mAdc, $I_B = 0$)	$V_{CEO(sus)}$	30	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	3.5	—	Vdc
Collector Cutoff Current ($V_{CE} = 28$ Vdc, $I_B = 0$)	I_{CEO}	—	0.02	mAdc
Collector Cutoff Current ($V_{CE} = 30$ Vdc, $V_{BE} = -1.5$ Vdc (Rev.), $T_C = 150°C$) ($V_{CE} = 55$ Vdc, $V_{BE} = -1.5$ Vdc (Rev.))	I_{CEX}	 — —	 5.0 0.1	mAdc
Emitter Cutoff Current ($V_{BE} = 3.5$ Vdc, $I_C = 0$)	I_{EBO}	—	0.1	mAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 360$ mAdc, $V_{CE} = 5.0$ Vdc)(1) ($I_C = 50$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	 5.0 10	 — 200	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 20$ mAdc)	$V_{CE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 15$ Vdc, f = 200 MHz)	f_T	500	—	MHz
Output Capacitance ($V_{CB} = 28$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	3.0	pF
FUNCTIONAL TEST				
Amplifier Power Gain ($V_{CC} = 28$ Vdc, $P_{out} = 1.0$ W, f = 400 MHz)	G_{pe}	10	—	dB
Collector Efficiency ($V_{CC} = 28$ Vdc, $P_{out} = 1.0$ W, f = 400 MHz)	η	45	—	%

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — 400 MHz TEST CIRCUIT SCHEMATIC



C1: 3.0 35 pF
C2, C5: 8.0 60 pF
C3: 12 pF
C4: 1000 pF
C6: 0.9–7.0 pF
L1: Two turns #18 Wire, 1/4″ ID, 1/8″ long
L2: FERRITE RF Choke, One Turn, z = 450 Ohms
L3, L4: RF Choke, 0.1 μH
L5: 2-3/4 Turns, #18 Wire, 1/4″ ID, 3/16″ long
R1: 5.6 Ohms

MPS3903
MPS3904

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Power Dissipation @ $T_A = 60°C$	P_D	450	mW
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)		$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 30$ Vdc, $V_{EB(off)} = 3.0$ Vdc)		I_{CEX}	—	50	nAdc
Base Cutoff Current ($V_{CE} = 30$ Vdc, $V_{EB(off)} = 3.0$ Vdc)		I_{BL}	—	50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain		h_{FE}			—
($I_C = 0.1$ mAdc, $V_{CE} = 1.0$ Vdc)	MPS3903 MPS3904		20 40	— —	
($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc)	MPS3903 MPS3904		35 70	— —	
($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)	MPS3903 MPS3904		50 100	150 300	
($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc)	MPS3903 MPS3904		30 60	— —	
$I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)	MPS3903 MPS3904		15 30	— —	
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{CE(sat)}$	 — —	 0.2 0.3	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{BE(sat)}$	 0.65 —	 0.85 1.0	Vdc

2

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MPS3903 MPS3904	f_T	150 200	— —	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	8.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS3903 MPS3904	h_{ie}	0.5 1.0	8.0 10	kΩ
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS3903 MPS3904	h_{re}	0.1 0.5	5.0 8.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS3903 MPS3904	h_{fe}	50 100	200 400	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	1.0	40	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kΩ, f = 10 Hz to 15.7 kHz)	MPS3903 MPS3904	NF	— —	6.0 5.0	dB
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_d	—	35	ns
Rise Time		t_r	—	50	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc) MPS3903 MPS3904	t_s	— —	800 900	ns
Fall Time		t_f	—	90	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

EQUIVALENT SWITCHING TIME TEST CIRCUITS

FIGURE 1 – TURN-ON TIME

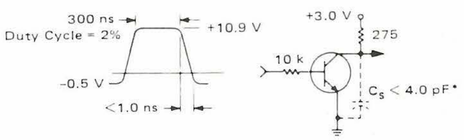
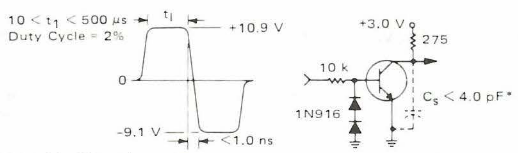


FIGURE 2 – TURN-OFF TIME



*Total shunt capacitance of test jig and connectors

TYPICAL NOISE CHARACTERISTICS
(V_{CE} = 5.0 Vdc, T_A = 25°C)

FIGURE 3 — NOISE VOLTAGE

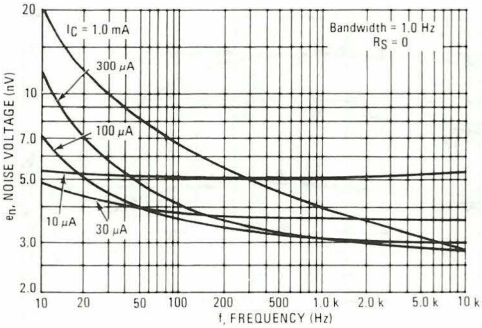
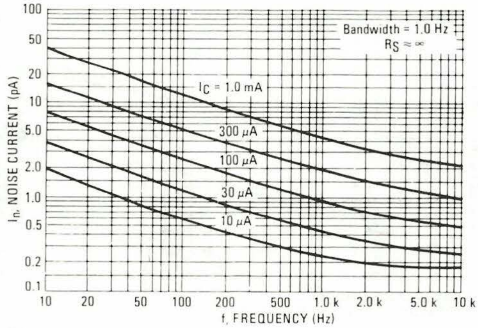


FIGURE 4 — NOISE CURRENT



NOISE FIGURE CONTOURS
(V_{CE} = 5.0 Vdc, T_A = 25°C)

FIGURE 5 — NARROW BAND, 100 Hz

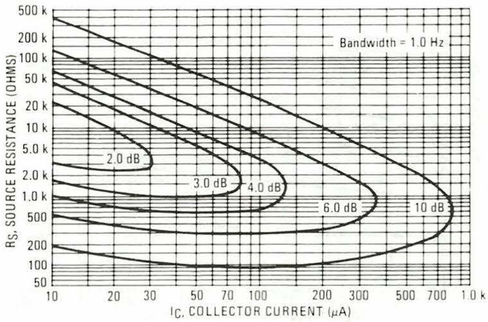


FIGURE 6 — NARROW BAND, 1.0 kHz

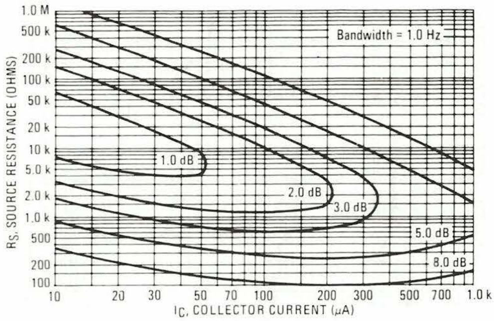
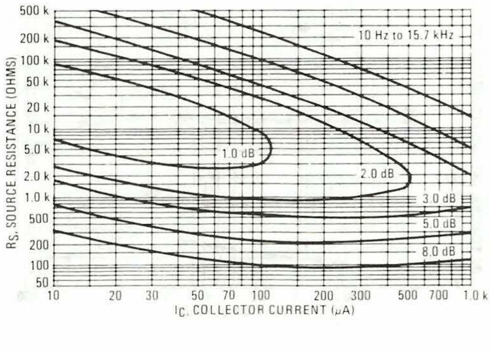


FIGURE 7 — WIDEBAND



Noise Figure is Defined as:

$$NF = 20 \log_{10} \left(\frac{e_n{}^2 + 4KTR_S + I_n{}^2 R_S{}^2}{4KTR_S} \right)^{1/2}$$

e_n = Noise Voltage of the Transistor referred to the input. (Figure 3)
I_n = Noise Current of the transistor referred to the input (Figure 4)
K = Boltzman's Constant (1.38×10^{-23} j/°K)
T = Temperature of the Source Resistance (°K)
R_S = Source Resistance (Ohms)

2

TYPICAL STATIC CHARACTERISTICS

FIGURE 8 — DC CURRENT GAIN

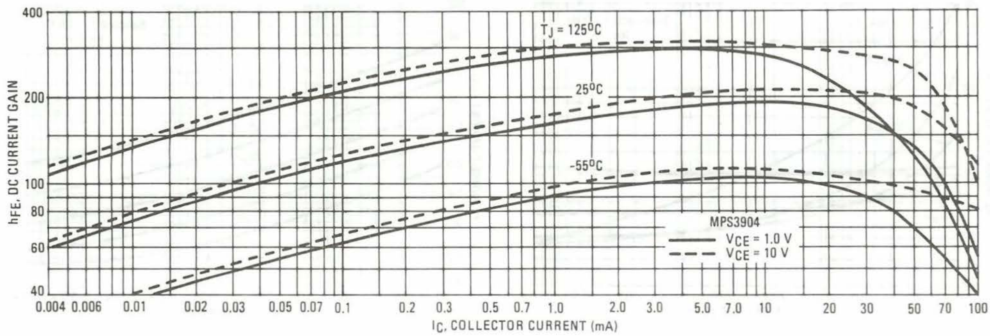


FIGURE 9 — COLLECTOR SATURATION REGION

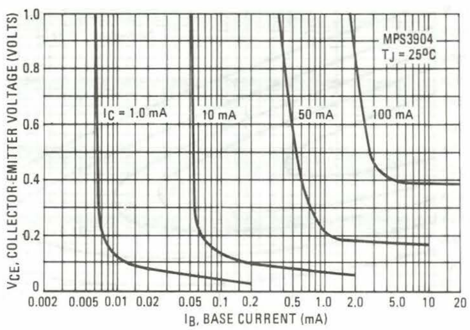


FIGURE 10 — COLLECTOR CHARACTERISTICS

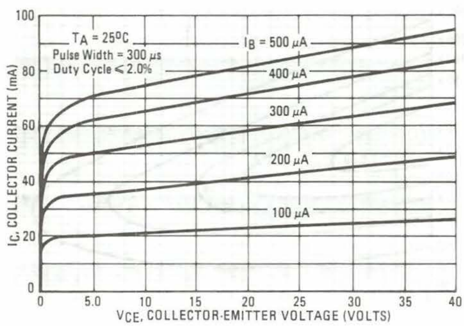


FIGURE 11 — "ON" VOLTAGES

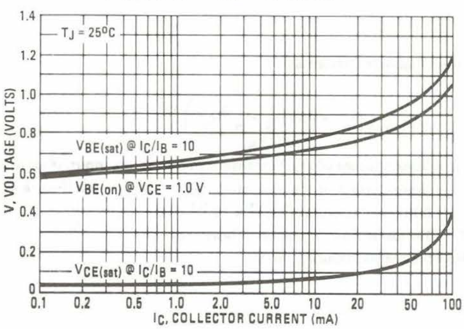
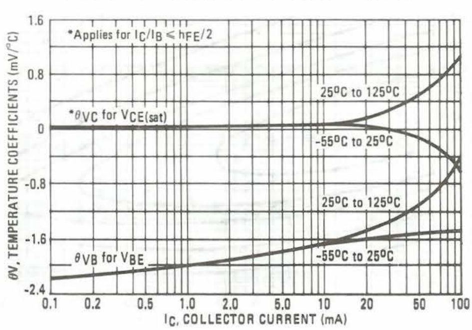


FIGURE 12 — TEMPERATURE COEFFICIENTS



2

TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 13 – TURN-ON TIME

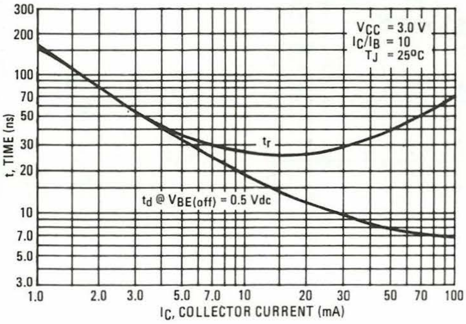


FIGURE 14 – TURN-OFF TIME

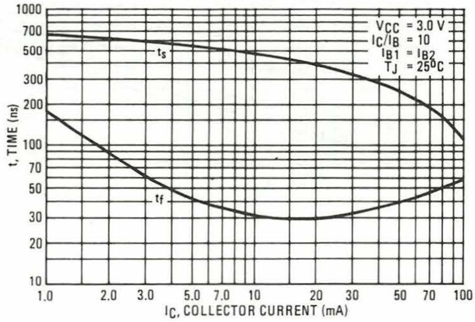


FIGURE 15 – CURRENT-GAIN – BANDWIDTH PRODUCT

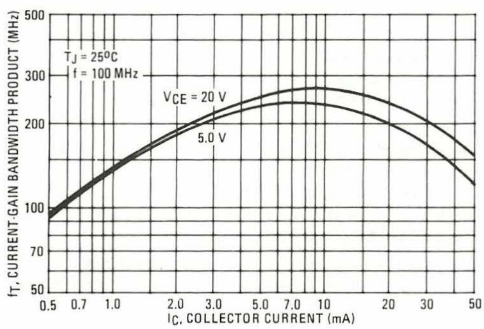


FIGURE 16 – CAPACITANCE

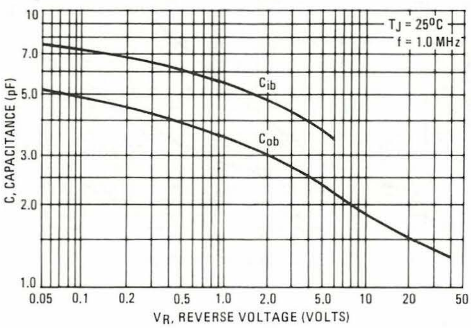


FIGURE 17 – INPUT IMPEDANCE

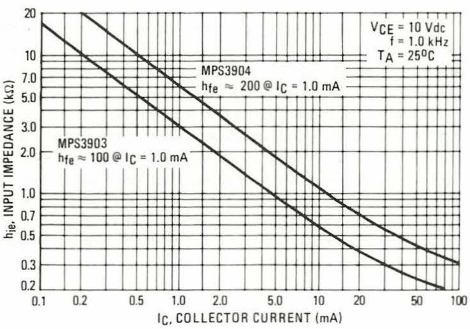
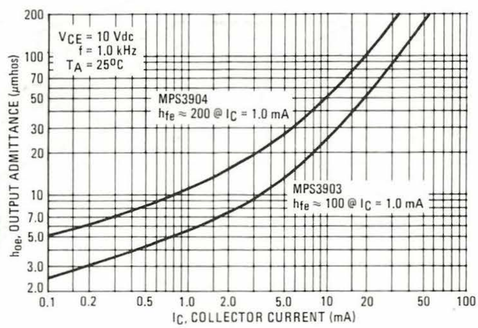


FIGURE 18 – OUTPUT ADMITTANCE



2

FIGURE 19 — THERMAL RESPONSE

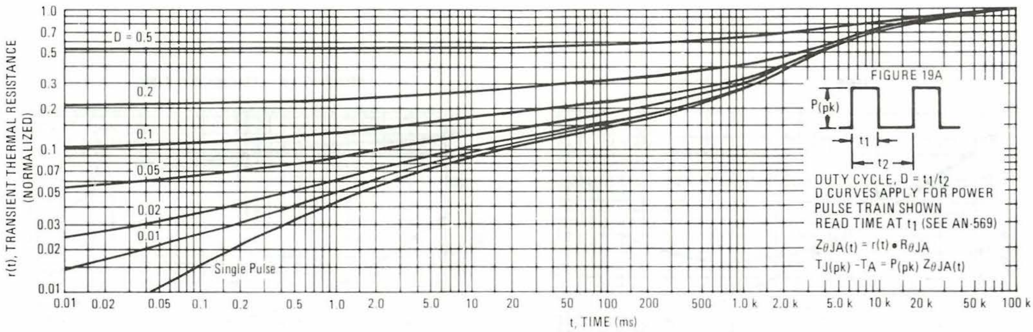
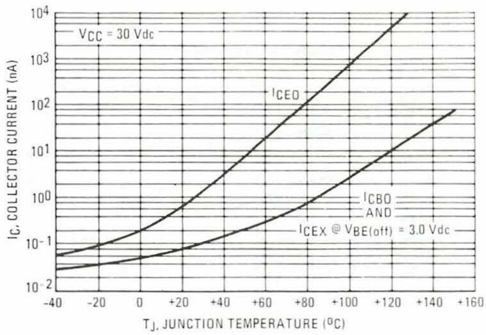


FIGURE 19A



DESIGN NOTE: USE OF THERMAL RESPONSE DATA

A train of periodical power pulses can be represented by the model as shown in Figure 19A. Using the model and the device thermal response the normalized effective transient thermal resistance of Figure 19 was calculated for various duty cycles.

To find $Z_{\theta JA(t)}$, multiply the value obtained from Figure 19 by the steady state value $R_{\theta JA}$.

Example:
The MPS3903 is dissipating 2.0 watts peak under the following conditions:

$t_1 = 1.0$ ms, $t_2 = 5.0$ ms. (D = 0.2)

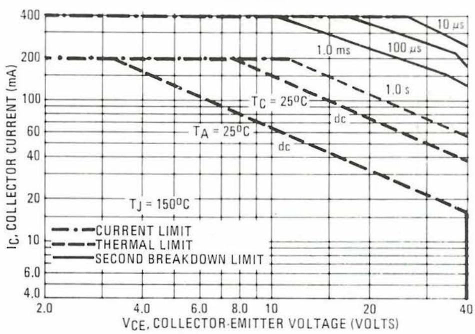
Using Figure 19 at a pulse width of 1.0 ms and D = 0.2, the reading of r(t) is 0.22.

The peak rise in junction temperature is therefore

$\Delta T = r(t) \times P_{(pk)} \times R_{\theta JA} = 0.22 \times 2.0 \times 200 = 88^\circ C.$

For more information, see AN-569.

FIGURE 20



The safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 20 is based upon $T_{J(pk)} = 150^\circ C$; T_C or T_A is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 150^\circ C$. $T_{J(pk)}$ may be calculated from the data in Figure 19. At high case or ambient temperatures, thermal limitations will reduce the power than can be handled to values less than the limitations imposed by second breakdown. (See AN-415A).

MPS3905
MPS3906

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to 2N5086 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Base Current	I_B	200	Vdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Power Dissipation @ $T_A = 60°C$	P_D	450	mW
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)		$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 30$ Vdc, $V_{BE(off)} = 3.0$ Vdc)		I_{CEX}	—	50	nAdc
Base Cutoff Current ($V_{CE} = 30$ Vdc, $V_{BE(off)} = 3.0$ Vdc		I_{BL}	—	50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 1.0$ Vdc)	MPS3905 MPS3906	h_{FE}	30 60	— —	—
($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc)	MPS3905 MPS3906		40 80	— —	
($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)	MPS3905 MPS3906		50 100	150 300	
($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc)	MPS3905 MPS3906		30 60	— —	
($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)	MPS3905 MPS3906		15 30	— —	
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{CE(sat)}$	 — —	 0.25 0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{BE(sat)}$	 0.65 —	 0.85 0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	MPS3905 MPS3906	f_T	200 250	— —	MHz

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	4.5	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	10	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS3905 MPS3906	h_{ie}	0.5 2.0	8.0 12	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS3905 MPS3906	h_{re}	0.1 1.0	5.0 10	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS3905 MPS3906	h_{fe}	50 100	200 400	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS3905 MPS3906	h_{oe}	1.0 3.0	40 60	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohm, f = 10 Hz to 15.7 kHz)	MPS3905 MPS3906	NF	— —	5.0 4.0	dB

SWITCHING CHARACTERISTICS

Characteristic	Conditions		Symbol	Min	Max	Unit
Delay Time	(V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 0.5 Vdc (I_C = 10 mAdc, I_{B1} = 1.0 mAdc)		t_d	—	35	ns
Rise Time			t_r	—	50	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	MPS3905 MPS3906	t_s	— —	500 600	ns
Fall Time		MPS3905 MPS3906	t_f	— —	90 90	ns

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

MPS4248
MPS4249
MPS4250
MPS4250A

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

TRANSISTOR

PNP SILICON

2

MAXIMUM RATINGS

Rating	Symbol	MPS4248 MPS4250	MPS4249 MPS4250A	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Emitter Voltage	V_{CES}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	40	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	5.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	1.5 12	mW mW/°C
Total Device Dissipation @ T_C = 100°C Derate above 100°C	P_D			
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +125		°C
Junction Temperature	T_J	125		°C
Lead Temperature (10 seconds)	T_L	260		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage		$V_{(BR)CES}$			Vdc
(I_C = 10 μA)	MPS4248		40	—	
(I_C = 10 μA)	MPS4249		60	—	
(I_C = 5.0 mA)	MPS4250		40	—	
(I_C = 5.0 mA)	MPS4250A		60	—	
Collector-Emitter Sustaining Voltage(1)		$V_{(BR)CEO(sus)}$			Vdc
(I_C = 5.0)	MPS4248, MPS4250		40	—	
(I_C = 5.0)	MPS4249, MPS4250A		60	—	
Collector-Base Breakdown Voltage		$V_{(BR)CBO}$			Vdc
(I_C = 10 μA)	MPS4248, MPS4250		40	—	
(I_C = 10 μA)	MPS4249, MPS4250A		60	—	
Emitter-Base Breakdown Voltage (I_E = 10 μA)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current		I_{CBO}			nA
(V_{CB} = 40 V)	MPS4248, MPS4249, MPS4250A		—	10	
(V_{CB} = 50 V)	MPS4250		—	10	
(V_{CB} = 40 V, T_A = 65°C)	MPS4248,49,50		—	3.0	
Emitter Cutoff Current (V_{BE} = 3.0 V)		I_{EBO}	—	20	nA
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 100 μA, V_{CE} = 5.0 V)	MPS4248		50	—	
(I_C = 100 μA, V_{CE} = 5.0 V)	MPS4249		100	300	
(I_C = 100 μA, V_{CE} = 5.0 V)	MPS4250,A		250	700	
(I_C = 1.0 mA, V_{CE} = 5.0 V)	MPS4248		50	—	
(I_C = 1.0 mA, V_{CE} = 5.0 V)	MPS4249		100	—	
(I_C = 1.0 mA, V_{CE} = 5.0 V)	MPS4250		250	—	
(I_C = 10 mA, V_{CE} = 5.0 V)	MPS4248		50	—	
(I_C = 10 mA, V_{CE} = 5.0 V)	MPS4249		100	—	
(I_C = 10 mA, V_{CE} = 5.0 V)	MPS4250		250	—	
Collector-Emitter Saturation Voltage(1) (I_C = 10 mA, I_B = 0.5 mA)		$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 10 mA, I_B = 0.5 mA)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 5.0 V, f = 1.0 MHz)		C_{obo}	—	6.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Input Capacitance (V_{BE} = 0.5 V, f = 1.0 MHz)		C_{ibo}	—	16	pF
Small-Signal Current Gain		h_{fe}			—
(I_C = 1.0 mA, V_{CE} = 5.0 V, f = 1.0 kHz)	MPS4248		50	1000	
(I_C = 1.0 mA, V_{CE} = 5.0 V, f = 1.0 kHz)	MPS4249		100	500	
(I_C = 1.0 mA, V_{CE} = 5.0 V, f = 1.0 kHz)	MPS4250,A		250	800	
(I_C = 0.5 mA, V_{CE} = 5.0 V, f = 20 MHz)	MPS4248,49,50		2.0	—	
Noise Figure		NF			dB
(I_C = 20 μA, V_{CE} = 5.0 V, R_S = 10 KΩ, f = 1.0 kHz, P_{BW} = 150 Hz)	MPS4248,50,A		—	2.0	
(I_C = 20 μA, V_{CE} = 5.0 V, R_S = 10 KΩ, f = 1.0 kHz, P_{BW} = 150 Hz)	MPS4249		—	3.0	
(I_C = 250 μA, V_{CE} = 5.0 V, R_S = 1.0 KΩ, f = 1.0 kHz, P_{BW} = 150 Hz)	MPS4248,50,A		—	2.0	
(I_C = 250 μA, V_{CE} = 5.0 V, R_S = 1.0 KΩ, f = 1.0 kHz, P_{BW} = 150 Hz)	MPS4249		—	3.0	

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

MPS4257
MPS4258

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

SWITCHING TRANSISTORS

PNP SILICON

Refer to MPS3640 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPS4257	MPS4258	Unit
Collector-Emitter Voltage	V_{CEO}	6.0	12	Vdc
Collector-Base Voltage	V_{CBO}	6.0	12	Vdc
Emitter-Base Voltage	V_{EBO}	4.5		Vdc
Collector Current — Continuous	I_C	80		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 12		mW mW°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

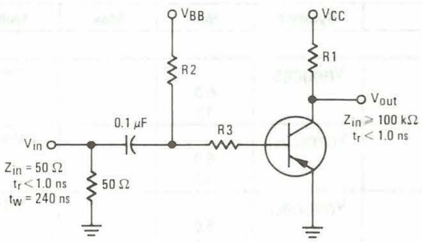
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 100\ \mu Adc$, $V_{BE} = 0$)	 MPS4257 MPS4258	$V_{(BR)CES}$	 6.0 12	 — —	Vdc
Collector-Emitter Sustaining Voltage(1) ($I_C = 3.0$ mAdc, $I_B = 0$)	 MPS4257 MPS4258	$V_{CEO(sus)}$	 6.0 12	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu Adc$, $I_E = 0$)	 MPS4257 MPS4258	$V_{(BR)CBO}$	 6.0 12	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu Adc$, $I_C = 0$)		$V_{(BR)EBO}$	4.5	—	Vdc
Collector Cutoff Current ($V_{CE} = 3.0$ Vdc, $V_{BE} = 0$) ($V_{CE} = 3.0$ Vdc, $V_{BE} = 0$, $T_A = +65°C$) ($V_{CE} = 6.0$ Vdc, $V_{BE} = 0$) ($V_{CE} = 6.0$ Vdc, $V_{BE} = 0$, $T_A = +65°C$)	 MPS4257 MPS4257 MPS4258 MPS4258	I_{CES}	 — — — —	 0.01 5.0 0.01 5.0	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 0.5$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 3.0$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc)		h_{FE}	 15 30 30	 — 120 —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{CE(sat)}$	 — —	 0.15 0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{BE(sat)}$	 0.75 —	 0.95 1.5	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	 MPS4257 MPS4258	f_T	 500 700	 — —	MHz
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)		C_{ibo}	—	3.5	pF
Collector-Base Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{cb}	—	3.0	pF

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic			Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS						
Turn-On Time	(V_{CC} = 1.5 Vdc, $V_{BE(off)}$ = 0, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)		t_{on}	—	15	ns
Delay Time			t_d	—	10	ns
Rise Time			t_r	—	15	ns
Turn-Off Time	(V_{CC} = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	MPS4257 MPS4258	t_{off}	— —	15 20	ns
Storage Time		MPS4257 MPS4258	t_s	— —	15 20	ns
Fall Time			t_f	—	10	ns
Storage Time ($I_C \approx$ 10 mAdc, $I_{B1} \approx$ 10 mAdc, $I_{B2} \approx$ 10 mAdc)		MPS4257 MPS4258	t_s	— —	15 20	ns

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



	V_{in} Volts	V_{BB} Volts	V_{CC} Volts	R1 Ohms	R2 Ohms	R3 Ohms	I_C mA	I_{B1} mA	I_{B2} mA
t_{on}	-5.8	GND	-1.5	130	2.2 k	5 k	10	1.0	–
t_{off}	+9.8	-8.0	-1.5	130	2.2 k	5 k	10	1.0	1.0
t_s	+9.0	-10	-3.0	270	510	390	10	10	10

2

MPS4274
MPS4275

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

SWITCHING TRANSISTOR

NPN SILICON

Refer to MPS2369 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPS4274	MPS4275	Unit
Collector-Emitter Voltage	V_{CEO}	12	15	Vdc
Collector-Emitter Voltage	V_{CES}	30	40	Vdc
Collector-Base Voltage	V_{CBO}	30	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.5		Vdc
Collector Current — Continuous	I_C	100		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0) MPS4274 MPS4275	$V_{(BR)CEO}$	 12 15	 — —	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{EB} = 0) MPS4274 MPS4275	$V_{(BR)CES}$	 30 40	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0) MPS4274 MPS4275	$V_{(BR)CBO}$	 30 40	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.5	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0, T_A = 65°C)	I_{CBO}	—	10	μAdc
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{EB} = 0)	I_{CES}	—	400	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 30 mAdc, V_{CE} = 0.4 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	35 30 18	120 — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 10 mAdc, I_B = 3.3 mAdc) (I_C = 30 mAdc, I_B = 3.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	— — — —	0.2 0.18 0.25 0.50	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 10 mAdc, I_B = 3.3 mAdc) (I_C = 30 mAdc, I_B = 3.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	0.72 0.74 — —	0.85 1.00 1.15 1.60	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, f = 1.0 MHz)	C_{cb}	—	4.0	pF
Small Signal Current Gain (I_C = 10 mAdc, V_{CB} = 10 Vdc, f = 100 MHz)	h_{fe}	4.0	—	—
SWITCHING CHARACTERISTICS				
Charge Storage Time (I_C = I_{B1} = I_{B2} = 10 mAdc, V_{CC} = 10 Vdc)	t_s	—	13	ns
Turn-On Time (I_C = 10 mAdc, I_{B1} = 3.3 mAdc, V_{CC} = 3.0 Vdc)	t_{on}	—	12	ns
Turn-Off Time (I_C = 10 mAdc, I_{B1} = I_{B2} = 3.3 mAdc, V_{CC} = 3.0 Vdc)	t_{off}	—	12	ns

(1) Pulse Test: Pulse Width ≤ 300 μSec, Duty Cycle ≤ 2.0%.

2

MPS5133

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

TRANSISTOR

NPN SILICON

Refer to MPS3903 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	.625	Watts
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0	Watt
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C
Lead Temperature (10 seconds)	T_L	260	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 3.0 mA)	$V_{(BR)CEO(sus)}$	18	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CBO}$	20	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μA)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current (V_{CB} = 15 V) (V_{CB} = 15 V, T_A = 65°C)	I_{CBO}	 — —	 50 5.0	 nA μA
Emitter Cutoff Current (V_{BE} = 2.0 V)	I_{EBO}	—	50	nA
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 mA, V_{CE} = 5.0 V)	h_{FE}	60	1000	—
Collector-Emitter Saturation Voltage (I_C = 1.0 mA, I_B = 0.1 mA)	$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter On Voltage (I_C = 100 μA, V_{CE} = 5.0 V)	$V_{BE(on)}$	—	0.75	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Collector-Base Capacitance (V_{CB} = 5.0 V)	C_{cb}	—	5.0	pF
Small-Signal Current Gain (I_C = 1.0 mA, V_{CE} = 5.0 V, f = 1.0 kHz) (I_C = 1.0 mA, V_{CE} = 5.0 V, f = 20 MHz)	h_{fe}	 50 2.0	 1100 20	—

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

MPS5138

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

TRANSISTOR

PNP SILICON

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	.625	Watts
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0	Watt
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C
Junction Temperature	T_J		°C
Lead Temperature (10 seconds)	T_L	260	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mA)	$V_{(BR)CEO(sus)}$	30	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μA)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 20 V) (V_{CB} = 20 V, T_A = 65°C)	I_{CBO}	 — —	 50 3.0	 nA μA
ON CHARACTERISTICS				
DC Current Gain (I_C = 100 μA, V_{CE} = 10 V) (I_C = 1.0 mA, V_{CE} = 10 V) (I_C = 10 mA, V_{CE} = 10 V)(1)	h_{FE}	 50 50 50	 800 — —	—
Collector-Emitter Saturation Voltage(1) (I_C = 10 mA, I_B = 0.5 mA)	$V_{CE(sat)}$	—	0.3	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 10 mA, I_B = 0.5 mA)	$V_{BE(sat)}$	—	1.0	Vdc
Base-Emitter On Voltage(1) (I_C = 10 mA, V_{CE} = 10 V)	$V_{BE(on)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Collector-Base Capacitance (V_{CB} = 5.0 V, f = 1.0 MHz)	C_{cb}	—	7.0	pF
Emitter-Base Capacitance (V_{BE} = 0.5 V, f = 1.0 MHz)	C_{eb}	—	30	pF
Small-Signal Current Gain (I_C = 0.5 mA, V_{CE} = 5.0 V, f = 20 MHz) (I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)	h_{fe}	 1.5 40	 — 1000	—

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

MPS5139

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

SWITCHING TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.625	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C
Lead Temperature (10 seconds)	T_L	260	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CES}$	20	—	Vdc
Collector-Emitter Sustaining Voltage (I_C = 10 mA)(1)	$V_{CEO(sus)}$	20	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CBO}$	20	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μA)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc) (V_{CE} = 15 Vdc, T_A = 65°C)	I_{CES}	 — —	 50 25	 nA μA
ON CHARACTERISTICS				
DC Current Gain (I_C = 100 μA, V_{CE} = 10 Vdc) (I_C = 1.0 mA, V_{CE} = 10 Vdc) (I_C = 10 mA, V_{CE} = 1.0 Vdc)(1) (I_C = 50 mA, V_{CE} = 10 Vdc)(1)	h_{FE}	 30 40 40 15	 — — — —	—
Collector-Emitter Saturation Voltage (I_C = 1.0 mA, I_B = 0.1 mA)(1) (I_C = 10 mA, I_B = 1.0 mA)(1) (I_C = 50 mA, I_B = 5.0 mA)(1)	$V_{CE(sat)}$	 — — —	 0.15 0.20 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mA, I_B = 1.0 mA)(1) (I_C = 50 mA, I_B = 5.0 mA)(1)	$V_{BE(sat)}$	 0.7 0.75	 1.0 1.25	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Collector-Base Capacitance (V_{CB} = 10 Vdc, f = 1.0 MHz)	C_{cb}	—	5.0	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, f = 1.0 MHz)	C_{eb}	—	8.0	pF
Current Gain — High Frequency (I_C = 10 mA, V_{CE} = 20 Vdc, f = 100 MHz)	$\|h_{fe}\|$	3.0	—	—
SWITCHING CHARACTERISTICS				
Turn-On Time (I_C ≈ 50 mA, I_{B1} ≈ 5.0 mA)	t_{on}	—	50	ns
Turn-Off Time (I_C ≈ 50 mA, I_{B1} ≈ 5.0 mA, I_{B2} ≈ −5.0 mA)	t_{off}	—	200	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

MPS5172

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MPS3903 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	25	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 25$ Vdc, $I_E = 0$) ($V_{CB} = 25$ Vdc, $I_E = 0$, $T_A = 100°C$)	I_{CBO}	 — —	 — —	 100 10	 nAdc μAdc
Collector Cutoff Current ($V_{CE} = 25$ Vdc, $V_{BE} = 0$)	I_{CES}	—	—	100	nAdc
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	100	—	500	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	—	0.25	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	—	0.75	—	Vdc
Base-Emitter On Voltage ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	$V_{BE(on)}$	0.5	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 2.0$ mAdc, $V_{CE} = 5.0$ Vdc)	f_T	—	120	—	MHz
Collector-Base Capacitance ($V_{CB} = 0$, $I_E = 0$, f = 1.0 MHz)	C_{cb}	1.6	—	10	pF
Small-Signal Current Gain ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{fe}	100	—	750	—

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

MPS5179

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

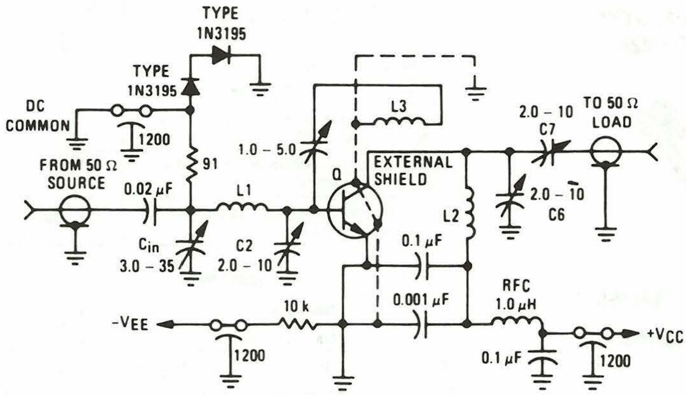
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	2.5	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	200 1.14	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	300 1.71	mW mW/°C
Storage Temperature Range	T_{stg}	−55 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 3.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	12	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.001 mAdc, I_E = 0)	$V_{(BR)CBO}$	20	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.01 mAdc, I_C = 0)	$V_{(BR)EBO}$	2.5	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 — —	 0.02 1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	25	250	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(1) (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 100 MHz)	f_T	900	2000	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{cb}	—	1.0	pF
Small Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)	h_{fe}	25	300	—
Collector Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 6.0 Vdc, f = 31.9 MHz)	$rb'C_c$	3.0	14	ps
Noise Figure (See Figure 1) (I_C = 1.5 mAdc, V_{CE} = 6.0 Vdc, R_S = 50 ohms, f = 200 MHz)	NF	—	4.5	dB
Common-Emitter Amplifier Power Gain (See Figure 1) (V_{CE} = 6.0 Vdc, I_C = 5.0 mAdc, f = 200 MHz)	G_{pe}	15	—	dB

(1) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 — 200 MHz AMPLIFIER POWER GAIN AND NOISE FIGURE CIRCUIT



L1 1-3/4 Turns, #18 AWG, 0.5" L, 0.5" Diameter
L2 2 Turns, #16 AWG, 0.5" L, 0.5" Diameter
L3 2 Turns, #13 AWG, 0.25" L, 0.5" Diameter (Position 1/4" from L2)

MPS6507

CASE 29-02, STYLE 2
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$) ($V_{CB} = 15$ Vdc, $I_E = 0$, $T_A = 60°C$)	I_{CBO}	 — —	 — —	 50 1.0	 nAdc μAdc
ON CHARACTERISTICS					
DC Current Gain(2) ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	25	75	—	—
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	700	800	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	1.25	2.5	pF
Small-Signal Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, f = 44 MHz)	h_{fe}	20	—	—	—

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPS6511

CASE 29-02, STYLE 2
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Emitter Voltage	V_{CES}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 0.5$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Emitter Breakdown Voltage(2) ($I_C = 100$ μAdc, $V_{EB} = 0$)	$V_{(BR)CES}$	30	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain(2) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	25	75	—	—
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	1.25	2.5	pF
FUNCTIONAL TEST					
Amplifier Power Gain ($I_C = 10$ mAdc, $V_{CB} = 12$ Vdc, f = 45 MHz)	G_{pe}	30	—	—	dB

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

NPN MPS6512 thru MPS6515 PNP MPS6516 thru MPS6519

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

Refer to 2N4125 for graphs.

MAXIMUM RATINGS

Rating	Symbol	NPN	PNP	Unit
Collector-Emitter Voltage	V_{CEO}			Vdc
MPS6512, MPS6513		30	—	
MPS6514, MPS6515		25	—	
MPS6516 thru MPS6518		—	40	
MPS6519		—	25	
Collector-Base Voltage	V_{CBO}			Vdc
MPS6512 thru MPS6515		40	—	
MPS6516 thru MPS6518		—	40	
MPS6519		—	25	
Emitter-Base Voltage	V_{EBO}	4.0	4.0	Vdc
Collector Current — Continuous	I_C	100	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$				Vdc
(I_C = 0.5 mAdc, I_B = 0)	MPS6512, MPS6513		30	—	—	
	MPS6514, MPS6515		25	—	—	
(I_C = 0.5 mAdc, I_B = 0)	MPS6516 thru MPS6518		40	—	—	
	MPS6519		25	—	—	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	4.0	—	—	Vdc
(I_E = 10 μAdc, I_C = 0)			4.0	—	—	
Collector Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 30 Vdc, I_E = 0)			—	—	0.05	
(V_{CB} = 30 Vdc, I_E = 0)	MPS6516 thru MPS6518		—	—	0.05	
(V_{CB} = 20 Vdc, I_E = 0)	MPS6519		—	—	0.05	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				—
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	MPS6512		50	—	100	
	MPS6513		90	—	180	
	MPS6514		150	—	300	
	MPS6515		250	—	500	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)(1)	MPS6512		30	—	—	
	MPS6513		60	—	—	
	MPS6514		90	—	—	
	MPS6515		150	—	—	
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	MPS6516		50	—	100	
	MPS6517		90	—	180	
	MPS6518		150	—	300	
	MPS6519		250	—	500	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)(1)	MPS6516		30	—	—	
	MPS6517		60	—	—	
	MPS6518		90	—	—	
	MPS6519		150	—	—	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	—	—	0.5	Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)			—	—	0.5	
SMALL-SIGNAL CHARACTERISTICS						
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	—	3.5	pF
(V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)			—	—	4.0	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MAXIMUM RATINGS

Rating	Symbol	NPN	PNP	Unit
Collector-Emitter Voltage	V_{CEO}			Vdc
MPS6520, MPS6521		25	—	
MPS6522, MPS6523		—	25	
Collector-Base Voltage	V_{CBO}			Vdc
MPS6520, MPS6521		40	—	
MPS6522, MPS6523		—	25	
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	100		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Printed Circuit Board Mounting)	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

NPN
MPS6520
MPS6521
PNP
MPS6522
MPS6523

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

Refer to MPS3903 for NPN graphs.*

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$			Vdc
(I_C = 0.5 mAdc, I_B = 0)			25	—	
(I_C = 0.5 mAdc, I_B = 0)			25	—	
Emitter-Base Breakdown Voltage		$V_{(BR)EBO}$			Vdc
(I_E = 10 μAdc, I_C = 0)			4.0	—	
(I_E = 10 μAdc, I_C = 0)			4.0	—	
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 30 Vdc, I_E = 0)			—	0.05	
(V_{CB} = 20 Vdc, I_E = 0)			—	0.05	
ON CHARACTERISTICS					
DC Current Gain		h_{FE}		—	—
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	MPS6520		100	—	
	MPS6521		150		
				400	
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	MPS6520		200	600	
	MPS6521		300		
				—	
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	MPS6522		100	—	
	MPS6523		150		
				400	
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	MPS6522		200	600	
	MPS6523		300		
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)			—	0.5	
(I_C = 50 mAdc, I_B = 5.0 mAdc)			—	0.5	
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance		C_{obo}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)			—	3.5	
(V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)			—	3.5	
Noise Figure		NF			dB
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kohms, Power Bandwidth = 15.7 kHz, 3.0 dB points @ 10 Hz and 10 kHz)			—	3.0	
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kohms, Power Bandwidth = 15.7 kHz, 3.0 dB points @ 10 Hz and 10 kHz)			—	3.0	

*Refer to 2N5086 for PNP graphs.

2

MPS6530 thru MPS6532

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N4400 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage MPS6530, MPS6531 MPS6532	V_{CEO}	 40 30	Vdc
Collector-Base Voltage MPS6530, MPS6531 MPS6532	V_{CBO}	 60 50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	600	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625	mW
Junction Temperature	T_J, T_{stg}	150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.2	°C/mW

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)	 MPS6530, MPS6531 MPS6532	$V_{(BR)CEO}$	 40 30	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	 MPS6530, MPS6531 MPS6532	$V_{(BR)CBO}$	 60 50	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_B = 10$ μAdc, $I_C = 0$) ($I_B = 10$ μAdc, $I_C = 0$)	 All Types All Types	$V_{(BR)EBO}$	 5.0 4.0	 — —	Vdc
Collector Cutoff Current ($V_{CB} = 40$ Vdc, $I_E = 0$) ($V_{CB} = 30$ Vdc, $I_E = 0$) ($V_{CB} = 40$ Vdc, $I_E = 0$, $T_A = 60°C$) ($V_{CB} = 30$ Vdc, $I_E = 0$, $T_A = 60°C$)	 MPS6530, MPS6531 MPS6532 MPS6530, MPS6531 MPS6532	I_{CBO}	 — — — —	 0.05 0.1 2.0 5.0	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc)	 MPS6530 MPS6531 MPS6530 MPS6531 MPS6532 MPS6530 MPS6531	h_{FE}	 30 60 40 90 30 25 50	 — — 120 270 — — —	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 10$ mAdc)	 MPS6530, MPS6532 MPS6531	$V_{CE(sat)}$	 — —	 0.5 0.3	Vdc
Base-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 10$ mAdc)	 MPS6530, MPS6531 MPS6532	$V_{BE(sat)}$	 — —	 1.0 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz) ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	 All Types All Types	C_{obo}	 — —	 5.0 7.0	pF

MPS6533 thru MPS6535

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N4402 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage MPS6533, MPS6534 MPS6535	V_{CEO}	 40 30	Vdc
Collector-Base Voltage MPS6533, MPS6534 MPS6535	V_{CBO}	 40 30	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	600	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625	mW
Junction Temperature	T_J, T_{stg}	150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.2	°C/mW

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	 MPS6533, MPS6534 MPS6535	$V_{(BR)CEO}$	 40 30	 — 	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	 MPS6533, MPS6534 MPS6535	$V_{(BR)CBO}$	 40 30	 — —	Vdc
Emitter-Base Breakdown Voltage (I_B = 10 μAdc, I_C = 0) (I_B = 10 μAdc, I_C = 0)	 All Types All Types	$V_{(BR)EBO}$	 5.0 4.0	 — —	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 60°C) (V_{CB} = 20 Vdc, I_E = 0, T_A = 60°C)	 All Types MPS6533, MPS6534 MPS6535	I_{CBO}	 — —	 0.05 2.0 5.0	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 10 Vdc)	 MPS6533 MPS6534 MPS6533 MPS6534 MPS6535 MPS6533 MPS6534	h_{FE}	 30 60 40 90 30 25 50	 — — 120 270 — — —	—
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	 MPS6533, MPS6535 MPS6534	$V_{CE(sat)}$	 — —	 0.5 0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	 MPS6533, MPS6534 MPS6535	$V_{BE(sat)}$	 — —	 1.0 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz) (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	 All Types All Types	C_{obo}	 — —	 5.0 7.0	pF

2

MPS6543

CASE 29-02, STYLE 2
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	35	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	25	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	35	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	—	—	0.1	μAdc
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)	I_{EBO}	—	—	1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain(2) (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	60	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	200	350	mVdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	750	950	mVdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 12 Vdc, f = 100 MHz)	f_T	750	1100	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	0.8	1.0	pF
Collector Base Time Constant (I_E = 4.0 mAdc, V_{CE} = 12 Vdc, f = 31.8 MHz)	$rb'C_c$	—	—	9.5	ps

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPS6544

CASE 29-02, STYLE 2
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MPSH20 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.81	mW mW/°C
Total Device Dissipation @ T_A = 60°C	P_D	210	mW
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_E = 0)	$V_{(BR)CEO}$	45	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CB} = 35 Vdc, I_E = 0)	I_{CBO}	—	0.5	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 30 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	—	—
Collector-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 3.0 mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Common-Emitter Reverse Transfer Capacitance (V_{CB} = 10 Vdc, I_C = 0, f = 100 kHz)	C_{re}	—	0.65	pF
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 45 MHz)	y_{oe}	—	0.10	mmhos
Output Voltage ($V_{in(RMS)}$ = 12 mV, f = 45 MHz)	V_{out}	1.0	—	Vdc

MPS6547

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	35	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

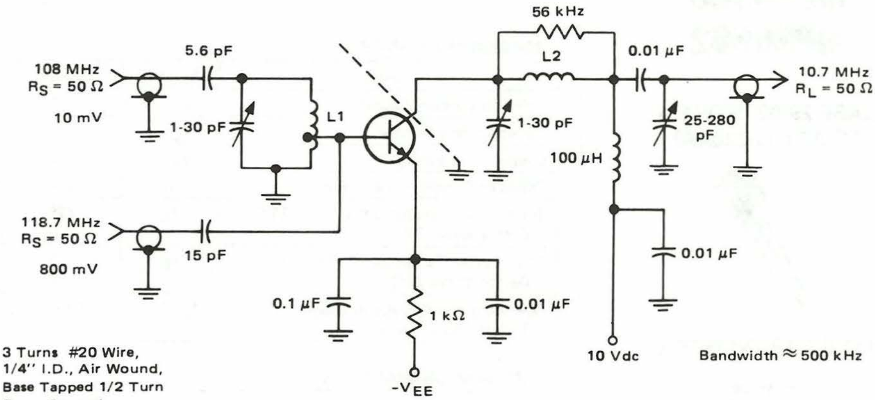
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	25	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	35	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	—	—	100	nAdc
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)	I_{EBO}	—	—	1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	20	60	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.1	0.35	Vdc
Base-Emitter On Voltage(2) (I_C = 10 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	—	0.7	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	600	1000	—	MHz
Common-Emitter Reverse Transfer Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{re}	—	0.3	0.35	pF
Conversion Gain (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz to 10.7 MHz)	G_{pe}	20	25	—	dB

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.



L1 = 3 Turns #20 Wire, 1/4" I.D., Air Wound, Base Tapped 1/2 Turn From Ground.

L2 = 37 Turns #28 Wire, Wound on 1/4" I.D. Coil Form.

2

MPS6560
MPS6562

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AUDIO TRANSISTOR

MPS6560
NPN SILICON

MPS6562
PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/mW
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/mW

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	25	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	25	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 25 Vdc, I_B = 0)	I_{CEO}	—	100	nAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{EB(off)}$ = 4.0 Vdc, I_C = 0)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(2)				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 35 50 50	 — — 200	—
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 30 MHz)	f_T	60	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	30	pF

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPS6565
MPS6566

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N3903 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

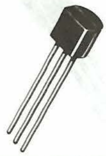
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	45	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)		$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)		I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	MPS6565 MPS6566	h_{FE}	40 100	— —	160 400	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)		$V_{CE(sat)}$	—	0.1	0.4	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 1.0$ MHz)		C_{obo}	—	—	3.5	pF

2

MPS6568A thru MPS6570A

CASE 29-02, STYLE 2
TO-92 (TO-226AA)



VHF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case(1)	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	20	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		$V_{(BR)CBO}$	20	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_C = 0)		I_{CBO}	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 5.0 Vdc)		h_{FE}	20	200	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	0.1	3.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)		$V_{BE(sat)}$	—	0.96	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	 MPS6568A MPS6569A, MPS6570A	f_T	 375 300	 800 800	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz, emitter guarded)	 MPS6568A/6570A	C_{cb}	—	0.65	pF
Noise Figure (V_{AGC} = 1.4 Vdc, R_S = 50 ohms, f = 200 MHz) (V_{AGC} = 2.75 Vdc, R_S = 50 ohms, f = 45 MHz)	 MPS6568A MPS6569A, MPS6570A	NF	 — —	 3.3 6.0	dB
FUNCTIONAL TEST					
Amplifier Power Gain (V_{AGC} = 1.4 Vdc, R_S = 50 ohms, f = 200 MHz) (V_{AGC} = 2.75 Vdc, R_S = 50 ohms, f = 45 MHz)	 MPS6568A MPS6569A, MPS6570A	G_{pe}	 20 22.5	 27 28.5	dB
Forward AGC Voltage (Gain Reduction = 30 dB, R_S = 50 ohms, f = 200 MHz) (Gain Reduction = 30 dB, R_S = 50 ohms, f = 45 MHz)	 MPS6568A MPS6569A MPS6570A	V_{AGC}	 4.0 4.4 5.2	 5.0 5.4 6.2	Vdc

AGC CHARACTERISTICS

V_{CC} = 12 Vdc, R_S = 50 OHMS, SEE FIGURES 9 AND 10

—— f = 45 MHz   – – f = 200 MHz

FIGURE 1 — POWER GAIN

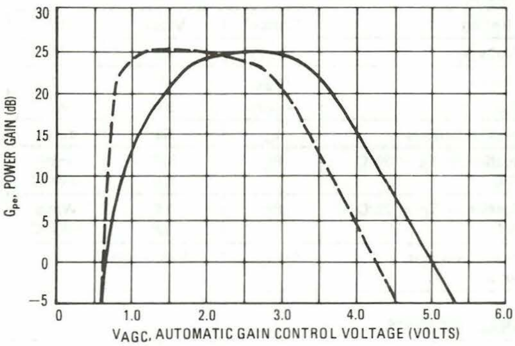


FIGURE 2 — NOISE FIGURE

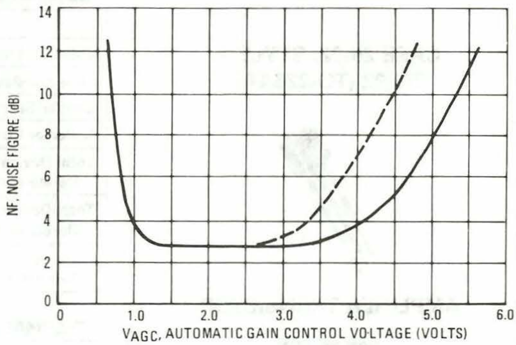
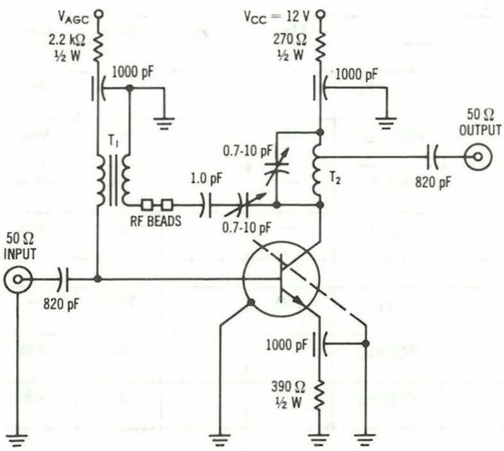
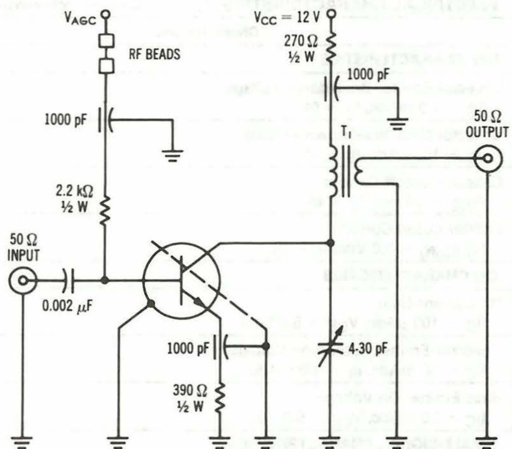


FIGURE 3 — 200 MHz FUNCTIONAL TEST CIRCUIT (NEUTRALIZED)



T_1 = FERRITE CORE INDIANA GEN. CORP. F-684
T_2 = 6 TURNS #16 BUSS WIRE, ID = ¼″, L = ¾″.

FIGURE 4 — 45 MHz FUNCTIONAL TEST CIRCUIT (UNNEUTRALIZED)



T_1 = TOROID 4:1 RATIO 8T-PRI 2T-SEC } #22 WIRE

MPS6571

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MPSA18 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ µAdc, $I_E = 0$)	$V_{(BR)CBO}$	25	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current ($V_{EB(off)} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 100$ µAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	250	—	1000	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	—	0.5	Vdc
Base-Emitter On Voltage ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	$V_{BE(on)}$	—	—	0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 500$ µAdc, $V_{CE} = 5.0$ Vdc, f = 20 MHz)	f_T	50	175	—	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	—	4.5	pF
Noise Figure ($I_C = 100$ µAdc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ kohms, f = 100 Hz)	NF	—	1.2	—	dB

MPS6573 thru MPS6576

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AUDIO TRANSISTOR

NPN SILICON

Refer to MPS3903 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	MPS6573 MPS6574	MPS6575 MPS6576	Unit
Collector-Emitter Voltage	V_{CEO}	35	45	Vdc
Collector-Base Voltage	V_{CBO}	35	45	Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	100		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 1.0$ mAdc, $I_B = 0$)	 MPS6573, MPS6574 MPS6575, MPS6576	$V_{(BR)CEO}$	 35 45	 — —	Vdc
Collector Cutoff Current ($V_{CB} = 35$ Vdc, $I_E = 0$) ($V_{CB} = 45$ Vdc, $I_E = 0$)	 MPS6573, MPS6574 MPS6575, MPS6576	I_{CBO}	 — —	 100 100	nAdc
Emitter Cutoff Current ($V_{EB} = 4.0$ Vdc, $I_C = 0$)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)(2) ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)	 MPS6573, MPS6575 MPS6573, MPS6575 MPS6574, MPS6576(2)	h_{FE}	 100 200 100	 — 500 300	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage(2) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)		$V_{BE(on)}$	—	0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 kHz)		f_T	100	350	MHz
Output Capacitance ($V_{CB} = 12$ Vdc, $I_E = 0$, f = 100 kHz)		C_{obo}	—	12	pF

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

MPS6580

CASE 29-02, STYLE 2
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

PNP SILICON

Refer to MPSH81 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	25	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	—	100	nAdc
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)	I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain(2) (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	80	—	—
Collector-Emitter Saturation Voltage (I_C = 2.0 mAdc, I_B = 0.2 mAdc)	$V_{CE(sat)}$	—	0.2	0.5	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	250	450	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 MHz)	C_{cb}	—	0.5	1.0	pF

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage MPS6601/6651 MPS6602/6652	V_{CEO}	 25 40	Vdc
Collector-Base Voltage MPS6601/6651 MPS6602/6652	V_{CBO}	 25 30	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	1000	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

NPN
MPS6601
MPS6602
PNP
MPS6651
MPS6652

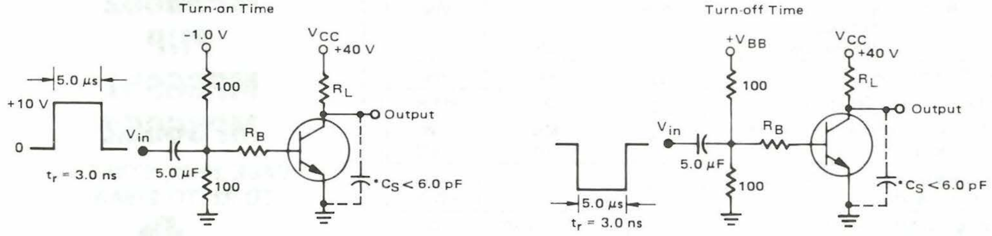
CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	 MPS6601/6651 MPS6602/6652	$V_{(BR)CEO}$	 25 40	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	 MPS6601/6651 MPS6602/6652	$V_{(BR)CBO}$	 25 40	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 25$ Vdc, $I_B = 0$) ($V_{CE} = 30$ Vdc, $I_B = 0$)	 MPS6601/6651 MPS6602/6652	I_{CEO}	 — —	 0.1 0.1	μAdc
Collector Cutoff Current ($V_{CB} = 25$ Vdc, $I_E = 0$) ($V_{CB} = 30$ Vdc, $I_E = 0$)	 MPS6601/6651 MPS6602/6652	I_{CBO}	 — —	 0.1 0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 500$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 1000$ mAdc, $V_{CE} = 1.0$ Vdc)		h_{FE}	 50 50 30	 — — —	—
Collector-Emitter Saturation Voltage ($I_C = 1000$ mAdc, $I_B = 100$ mAdc)		$V_{CE(sat)}$	—	0.6	Vdc
Base-Emitter On Voltage ($I_C = 500$ mAdc, $V_{CE} = 1.0$ Vdc)		$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 30 MHz)		f_T	100	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)		C_{obo}	—	30	pF
SWITCHING CHARACTERISTICS					
Delay Time	($V_{CC} = 40$ Vdc, $I_C = 500$ mAdc, $I_{B1} = 50$ mAdc, $t_p \geq 300$ ns Duty Cycle)	t_d	—	25	ns
Rise Time		t_r	—	30	ns
Storage Time		t_s	—	250	ns
Fall Time		t_f	—	50	ns

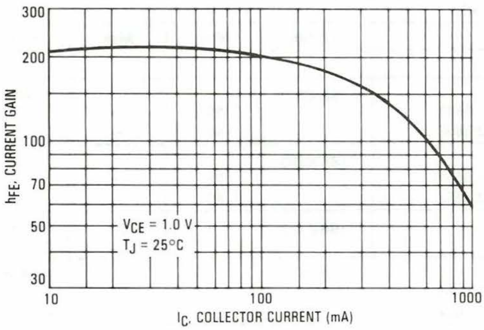
FIGURE 1 — SWITCHING TIME TEST CIRCUITS



*Total Shunt Capacitance of Test Jig and Connectors
For PNP Test Circuits, Reverse All Voltage Polarities

NPN

FIGURE 2 — MPS6601/6602 DC CURRENT GAIN



PNP

FIGURE 3 — MPS6651/6652 DC CURRENT GAIN

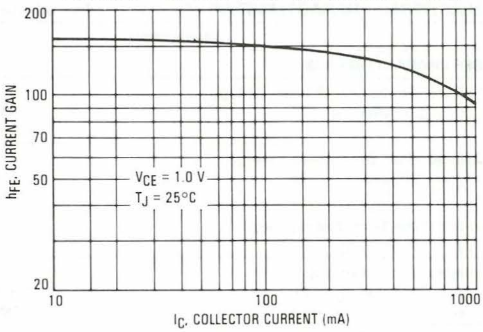


FIGURE 4 — CURRENT GAIN BANDWIDTH PRODUCT

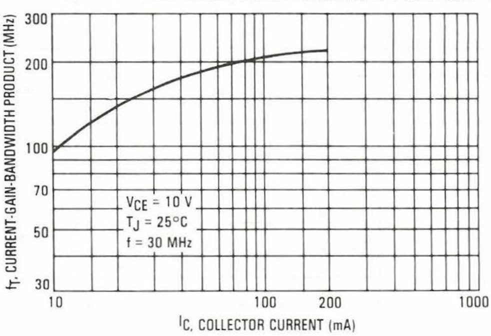


FIGURE 5 — CURRENT GAIN BANDWIDTH PRODUCT

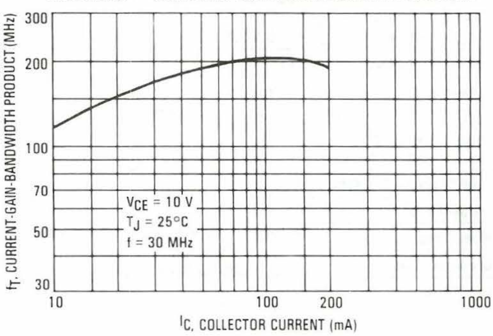


FIGURE 6 — ON VOLTAGES

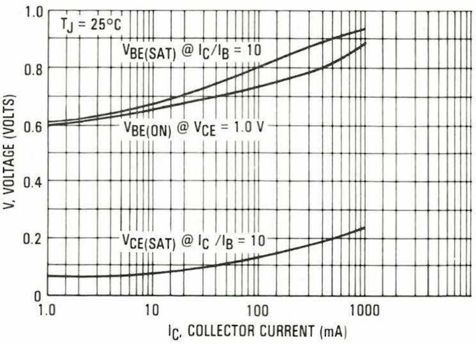
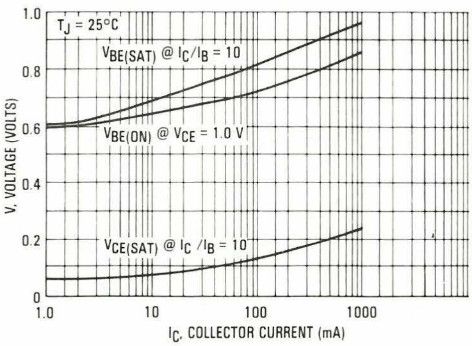
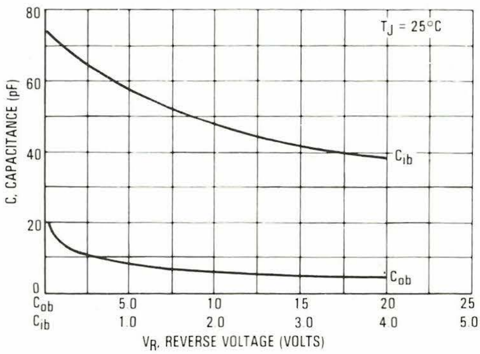


FIGURE 7 — ON VOLTAGES



NPN

FIGURE 8 — CAPACITANCE



PNP

FIGURE 9 — CAPACITANCE

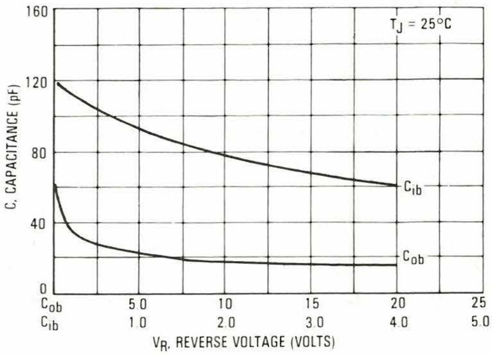


FIGURE 10 — MPS6601/6602 NOISE FIGURE

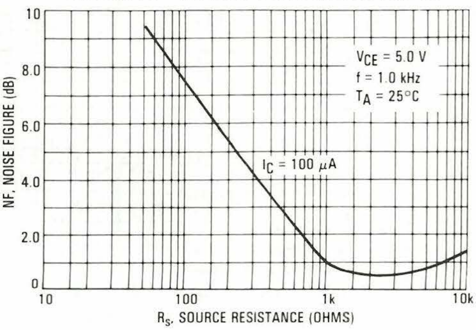
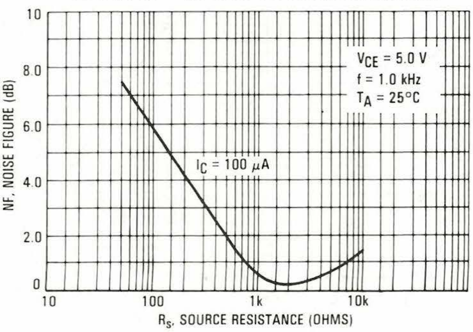


FIGURE 11 — MPS6651/6652 NOISE FIGURE



2

FIGURE 12 — MPS6601/6602 SWITCHING TIMES

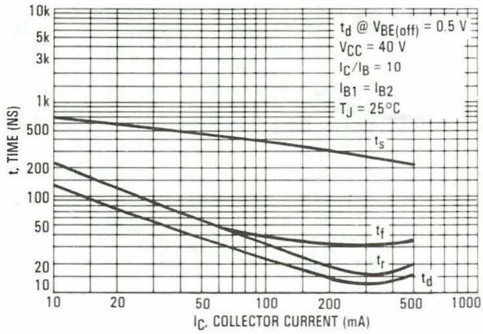
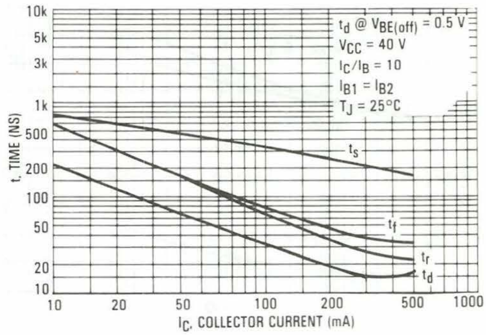
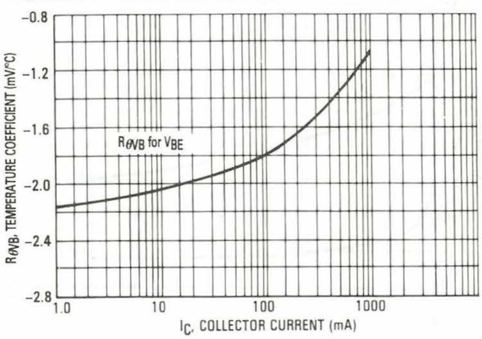


FIGURE 13 — MPS6651/6652 SWITCHING TIMES



NPN

FIGURE 14 — BASE-EMITTER TEMPERATURE COEFFICIENT



PNP

FIGURE 15 — BASE-EMITTER TEMPERATURE COEFFICIENT

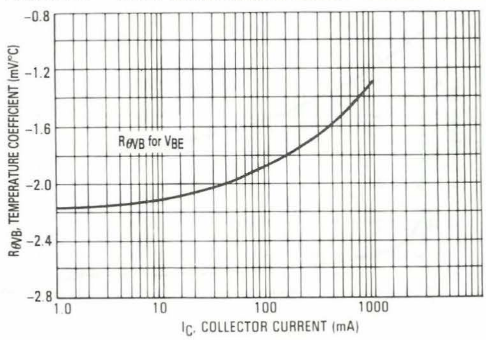


FIGURE 16 — SAFE OPERATING AREA

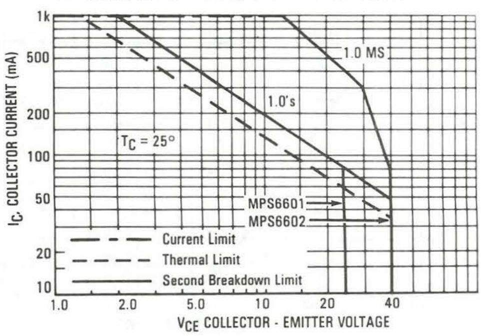


FIGURE 17 — SAFE OPERATING AREA

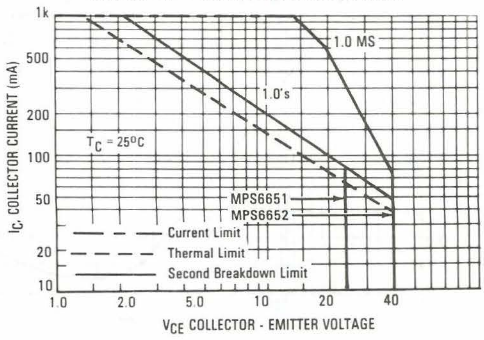


FIGURE 18 — MPS6601/6602 SATURATION REGION

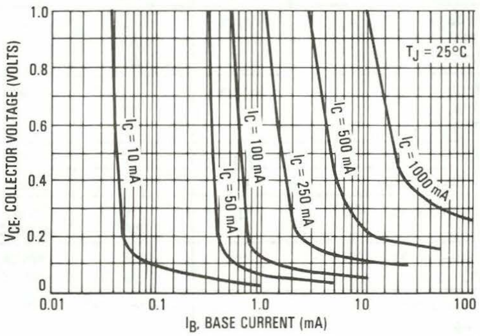


FIGURE 19 — MPS6651/6652 SATURATION REGION

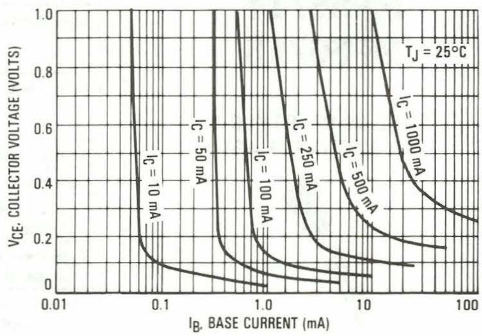
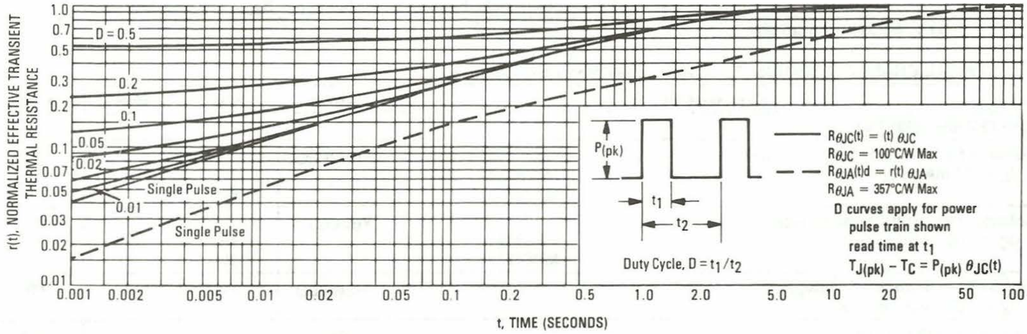


FIGURE 20 — THERMAL RESPONSE



2

MPS6714
MPS6715

CASE 29-03, STYLE 1
TO-92 (TO-226 AE)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MPSW01 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage MPS6714 MPS6715	V_{CEO}	 30 40	Vdc
Collector-Base Voltage MPS6714 MPS6715	V_{CBO}	 40 50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	 MPS6714 MPS6715	$V_{(BR)CEO}$	 30 40	 —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	 MPS6714 MPS6715	$V_{(BR)CBO}$	 40 50	 —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 40$ Vdc, $I_E = 0$) ($V_{CB} = 50$ Vdc, $I_E = 0$)	 MPS6714 MPS6715	I_{CBO}	 — —	 0.1 0.1	μAdc
Emitter Cutoff Current ($V_{EB} = 5.0$ Vdc, $I_C = 0$)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 1000$ mAdc, $V_{CE} = 1.0$ Vdc)		h_{FE}	 60 50	 — 250	—
Collector-Emitter Saturation Voltage ($I_C = 1000$ mAdc, $I_B = 100$ mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage ($I_C = 1000$ mAdc, $V_{CE} = 1.0$ Vdc)		$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{cb}	—	30	pF
Small-Signal Current Gain ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)		h_{fe}	2.5	25	—

(1) Pulse Test: Pulse Width ≤ 30 μs, Duty Cycle ≤ 2.0%.

MPS6716
MPS6717

CASE 29-03, STYLE 1
TO-92 (TO-226 AE)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MPSW05 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	MPS6516	MPS6517	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.5 20		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

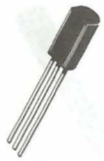
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $_B = 0$)	 MPS6716 MPS6717	$V_{(BR)CEO}$	 60 80	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	 MPS6716 MPS6717	$V_{(BR)CBO}$	 60 80	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 40$ Vdc, $I_E = 0$) ($V_{CB} = 60$ Vdc, $I_E = 0$)	 MPS6716 MPS6717	I_{CBO}	 — —	 0.1 0.1	μAdc
Emitter Cutoff Current ($V_{EB} = 5.0$ Vdc, $I_C = 0$)		I_{EBO}	—	10	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 250$ mAdc, $V_{CE} = 1.0$ Vdc)		h_{FE}	 80 50	 — 250	—
Collector-Emitter Saturation Voltage ($I_C = 250$ mAdc, $I_B = 10$ mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage ($I_C = 250$ mAdc, $V_{CE} = 1.0$ Vdc)		$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{cb}	—	30	pF
Small-Signal Current Gain ($I_C = 200$ mAdc, $V_{CE} = 5.0$ Vdc, f = 20 MHz)		h_{fe}	2.5	25	—

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

MPS6724
MPS6725

CASE 29-03, STYLE 1
(TO-226 AE)



DARLINGTON TRANSISTOR

NPN SILICON

Refer to 2N6426 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPS6724	MPS6725	Unit
Collector-Emitter Voltage	V_{CES}	40	50	Vdc
Collector-Base Voltage	V_{CBO}	50	60	Vdc
Emitter-Base Voltage	V_{EBO}	12		Vdc
Collector Current — Continuous	I_C	1000		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.5 20		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	 MPS6724 MPS6725	$V_{(BR)CES}$	 40 50	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 1.0$ μAdc, $I_E = 0$)	 MPS6724 MPS6725	$V_{(BR)CBO}$	 50 60	 — —	 Vdc Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	12	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$) ($V_{CB} = 40$ Vdc, $I_E = 0$)	 MPS6724 MPS6725	I_{CBO}	 — —	 100 100	nAdc
Emitter Cutoff Current ($V_{EB} = 10$ Vdc, $I_C = 0$)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 200$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 1000$ mAdc, $V_{CE} = 5.0$ Vdc)		h_{FE}	 25,000 4,000	 — 40,000	—
Collector-Emitter Saturation Voltage ($I_C = 1000$ mAdc, $I_B = 2.0$ mAdc)		$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage ($I_C = 1000$ mAdc, $V_{CE} = 5.0$ Vdc)		$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 200$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)		f_T	100	1000	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{cb}	—	10	pF

MPS6726
MPS6727

CASE 29-03, STYLE 1
TO-92 (TO-226 AE)

AMPLIFIER TRANSISTOR

PNP SILICON

Refer to MPSW51 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage MPS6726 MPS6727	V_{CEO}	 30 40	Vdc
Collector-Base Voltage MPS6726 MPS6727	V_{CBO}	 40 50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)	 MPS6726 MPS6727	$V_{(BR)CEO}$	 30 40	 —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	 MPS6726 MPS6727	$V_{(BR)CBO}$	 40 50	 —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 40$ Vdc, $I_E = 0$) ($V_{CB} = 50$ Vdc, $I_E = 0$)	 MPS6726 MPS6727	I_{CBO}	 —	 0.1 0.1	μAdc
Emitter Cutoff Current ($V_{EB} = 5.0$ Vdc, $I_C = 0$)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 1000$ mAdc, $V_{CE} = 1.0$ Vdc)		h_{FE}	 60 50	 — 250	—
Collector-Emitter Saturation Voltage ($I_C = 1000$ mAdc, $I_B = 100$ mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage ($I_C = 1000$ mAdc, $V_{CE} = 1.0$ Vdc)		$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{cb}	—	30	pF
Small-Signal Current Gain ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)		h_{fe}	2.5	25	—

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

MPS6728
MPS6729

CASE 29-03, STYLE 1
TO-92 (TO-226 AE)

AMPLIFIER TRANSISTOR

PNP SILICON

Refer to MPSW55 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPS6728	MPS6729	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.5 20		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	 MPS6728 MPS6729	$V_{(BR)CEO}$	 60 80	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	 MPS6728 MPS6729	$V_{(BR)CBO}$	 60 80	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{EB} = 5.0$ Vdc, $I_C = 0$)		I_{EBO}	—	10	μAdc
Emitter Cutoff Current ($V_{CB} = 40$ Vdc, $I_E = 0$) ($V_{CB} = 60$ Vdc, $I_E = 0$)	 MPS6728 MPS6729	I_{CBO}	 — —	 0.1 0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 250$ mAdc, $V_{CE} = 1.0$ Vdc)		h_{FE}	 80 50	 — 250	 — —
Collector-Emitter Saturation Voltage ($I_C = 250$ mAdc, $I_B = 10$ mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage ($I_C = 250$ mAdc, $V_{CE} = 1.0$ Vdc)		$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{cb}	—	30	pF
Small-Signal Current Gain ($I_C = 200$ mAdc, $V_{CE} = 5.0$ Vdc, f = 20 MHz)		h_{fe}	2.5	25	—

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPS6733
MPS6734
MPS6735

CASE 29-03, STYLE 1
TO-92 (TO-226 AE)

HIGH VOLTAGE TRANSISTOR

NPN SILICON

Refer to MPSW42 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	MPS6735	MPS6734	MPS6733	Unit
Collector-Emitter Voltage	V_{CEO}	300	250	200	Vdc
Collector-Base Voltage	V_{CBO}	300	250	200	Vdc
Emitter-Base Voltage	V_{EBO}		6.0		Vdc
Collector Current — Continuous	I_C		300		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D		1.0 8.0		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D		2.5 20		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	MPS6735 MPS6734 MPS6733	$V_{(BR)CEO}$	300 250 200	— — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	MPS6735 MPS6734 MPS6733	$V_{(BR)CBO}$	300 250 200	— — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 260$ Vdc, $I_E = 0$) ($V_{CB} = 200$ Vdc, $I_E = 0$) ($V_{CB} = 160$ Vdc, $I_E = 0$)	MPS6735 MPS6734 MPS6733	I_{CBO}	— — —	0.1 0.1 0.1	μAdc
Emitter Cutoff Current ($V_{EB} = 6.0$ Vdc, $I_C = 0$)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)		h_{FE}	25 40	— 200	—
Collector-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		$V_{CE(sat)}$	—	2.0	Vdc
Base-Emitter On Voltage ($I_C = 20$ mAdc, $V_{CE} = 10$ Vdc)		$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 20 MHz)		f_T	50	200	MHz
Collector-Base Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{cb}	—	3.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

MPS8093

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to 2N4402 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 60°C	P_D	450	mW
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

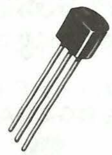
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 20 V)	I_{CBO}	—	100	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 V)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	100	300	—
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter On Voltage (I_C = 50 mAdc, V_{CE} = 2.0 V)	$V_{BE(on)}$	0.6	1.0	Vdc

MPS8097

CASE 29-02, STYLE 1
TO-92 (TO-226AA)



AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MPSA18 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0)	I_{CBO}	 — —	 30 10	 nAdc μAdc
Emitter Cutoff Current (V_{BE} = 6.0 Vdc, I_C = 0)	I_{EBO}	—	20	nAdc
ON CHARACTERISTICS(2)				
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	h_{FE}	250	700	—
Base-Emitter On Voltage (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	0.45	0.65	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	1.0	4.0	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{eb}	—	10	pF
Small-Signal Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	250	800	—
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = kOhms, f = 10 Hz to 15.7 KHz)	NF	—	2.0	dB
Equivalent Short Circuit Noise Voltage (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kOhms, f = 100 Hz, Bw = 1.0 Hz)	e_n	—	32	nV/$\sqrt{Hz}$

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

NPN MPS8098 MPS8099 PNP MPS8598 MPS8599

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

MAXIMUM RATINGS

Rating	Symbol	MPS8098 MPS8598	MPS8099 MPS8599	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
		MPS8098 MPS8099	**MPS8598 MPS8599**	
Emitter-Base Voltage	V_{EBO}	6.0	5.0	Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12.0		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

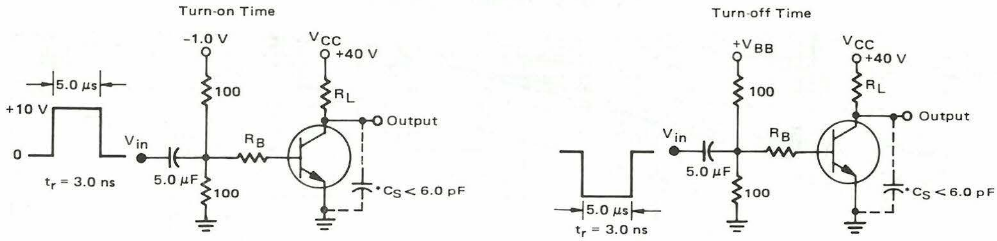
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	 MPS8098, MPS8598 MPS8099, MPS8599	$V_{(BR)CEO}$	 60 80	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 MPS8098, MPS8598 MPS8099, MPS8599	$V_{(BR)CBO}$	 60 80	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	 MPS8098, MPS8099 MPS8598, MPS8599	$V_{(BR)EBO}$	 6.0 5.0	 — —	Vdc
Collector Cutoff Current (V_{CE} = 60 Vdc, I_B = 0)		I_{CEO}	—	0.1	μAdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 80 Vdc, I_E = 0)	 MPS8098, MPS8598 MPS8099, MPS8599	I_{CBO}	 — —	 0.1 0.1	μAdc
Emitter Cutoff Current (V_{EB} = 6.0 Vdc, I_C = 0) (V_{EB} = 4.0 Vdc, I_C = 0)	 MPS8098, MPS8099 MPS8598, MPS8599	I_{EBO}	 — —	 0.1 0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) 0(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)		h_{FE}	100 100 75	300 — —	—
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 5.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{CE(sat)}$	— —	0.4 0.3	Vdc
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	 MPS8098, MPS8598 MPS8099, MPS8599	$V_{BE(on)}$	 0.5 0.6	 0.7 0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	150	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	 MPS8098, MPS8099 MPS8598, MPS8599	C_{obo}	 — —	 6.0 8.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	 MPS8098, MPS8099 MPS8598, MPS8599	C_{ibo}	 — —	 25 30	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.

FIGURE 1 – SWITCHING TIME TEST CIRCUITS



*Total Shunt Capacitance of Test Jig and Connectors
For PNP Test Circuits, Reverse All Voltage Polarities

FIGURE 2 – CURRENT-GAIN – BANDWIDTH PRODUCT

NPN MPS8098, MPS8099 | **PNP MPS8598, MPS8599**

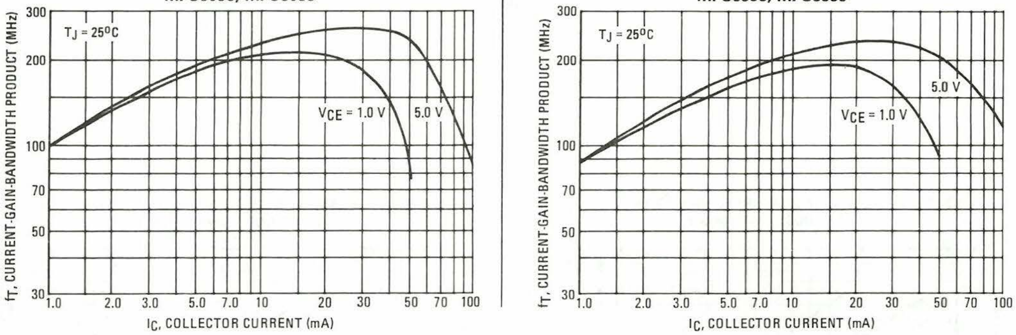


FIGURE 3 – CAPACITANCE

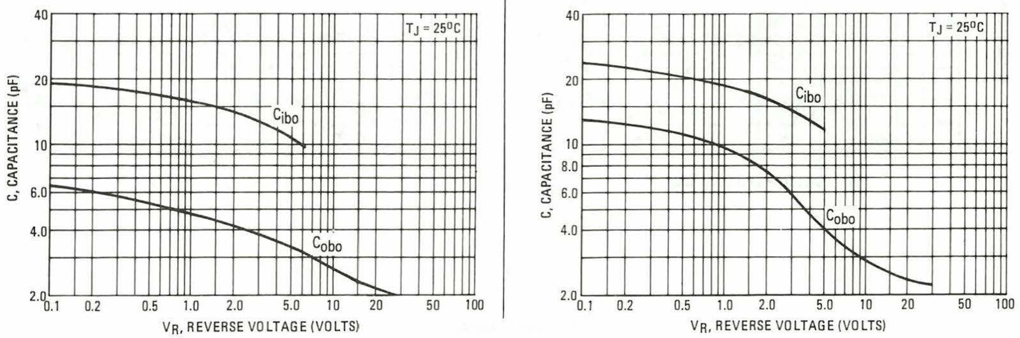


FIGURE 4 – SWITCHING TIMES

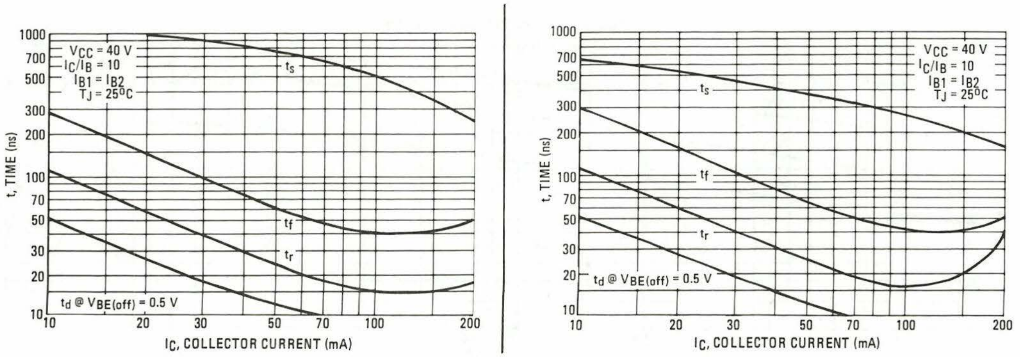


FIGURE 5 – THERMAL RESPONSE

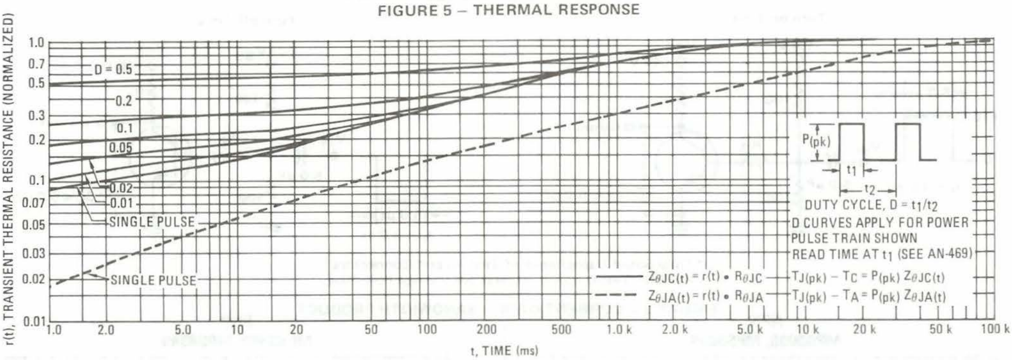


FIGURE 6—ACTIVE REGION, SAFE OPERATING AREA
MPS 8098, MPS 8099

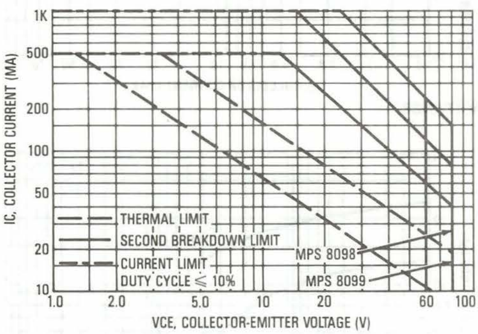
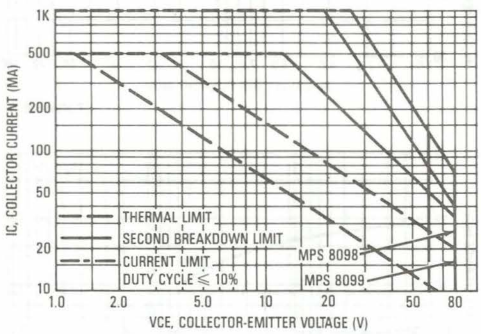


FIGURE 6—ACTIVE REGION, SAFE OPERATING AREA
MPS 8598, MPS 8599



MPS8098, MPS8099

FIGURE 7 – DC CURRENT GAIN

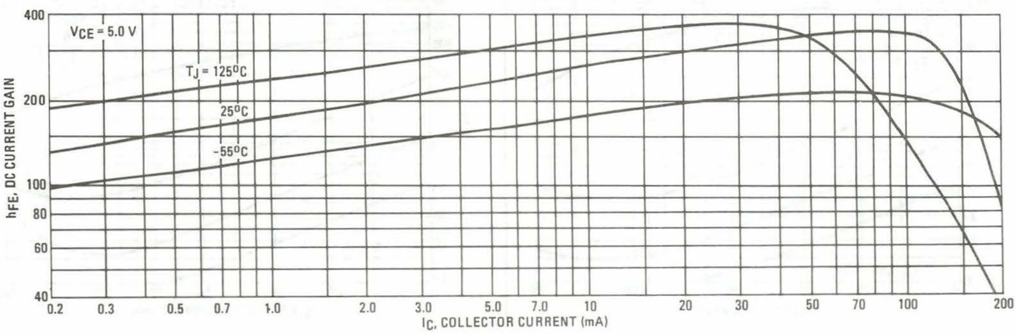


FIGURE 8 — "ON" VOLTAGES

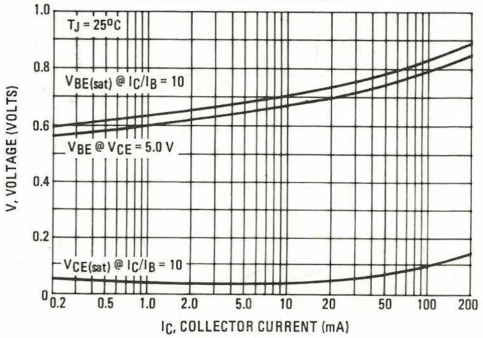


FIGURE 9 — COLLECTOR SATURATION REGION

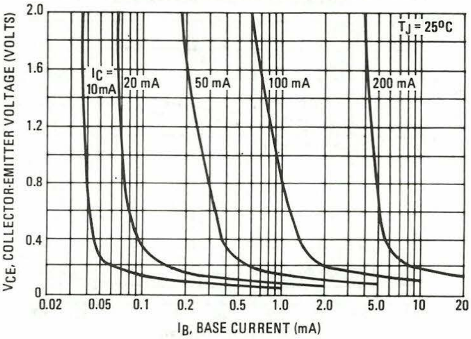
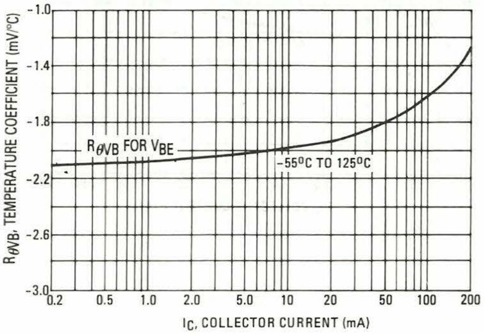


FIGURE 10 — BASE-EMITTER TEMPERATURE COEFFICIENT



MPS8598, MPS8599

FIGURE 11 — DC CURRENT GAIN

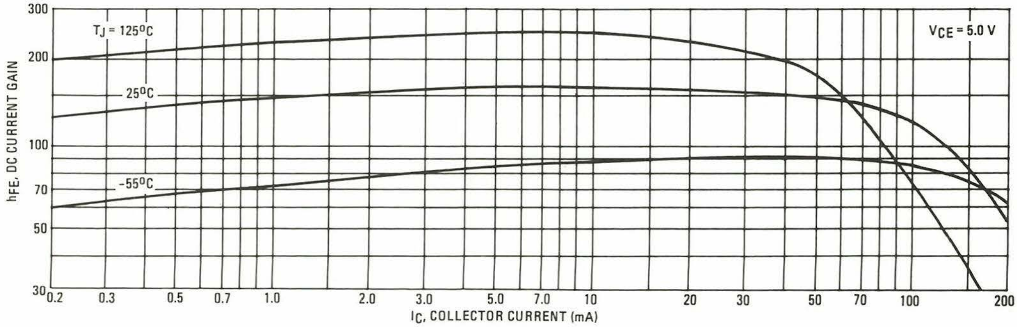


FIGURE 12 — "ON" VOLTAGES

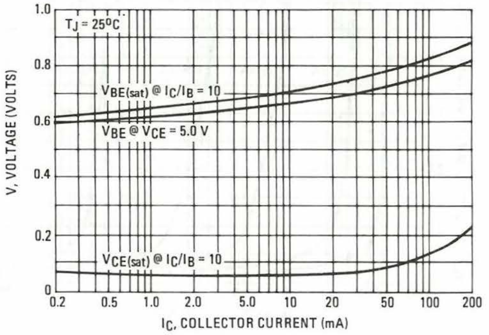


FIGURE 13 — COLLECTOR SATURATION REGION

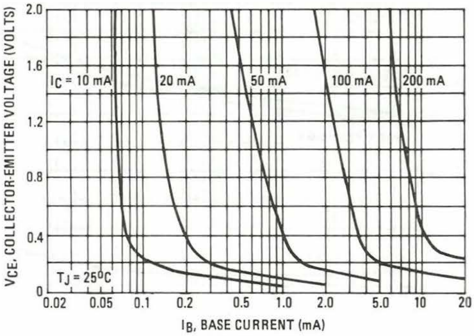
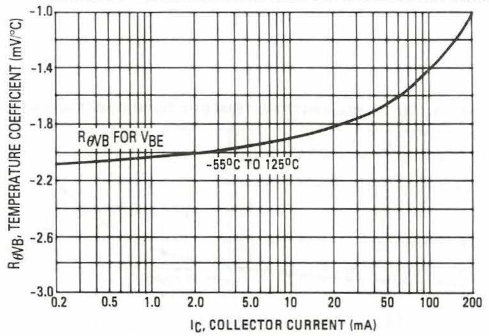


FIGURE 14 — BASE-EMITTER TEMPERATURE COEFFICIENT



2

NPN MPSA05 MPSA06 PNP MPSA55 MPSA56

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

MAXIMUM RATINGS

Rating	Symbol	MPSA05 MPSA55	MPSA06 MPSA56	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W

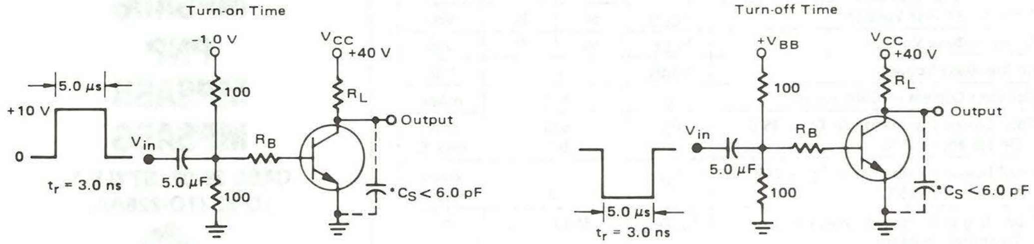
(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	 MPSA05, MPSA55 MPSA06, MPSA56	$V_{(BR)CEO}$	 60 80	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 60$ Vdc, $I_B = 0$)		I_{CEO}	—	0.1	μAdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 80$ Vdc, $I_E = 0$)	 MPSA05, MPSA55 MPSA06, MPSA56	I_{CBO}	 — —	 0.1 0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)		h_{FE}	 50 50	 — —	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 10$ mAdc)		$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter On Voltage ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)		$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 10$ mA, $V_{CE} = 2.0$ V, f = 100 MHz) ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc, f = 100 MHz)	 MPSA05 MPSA06 MPSA55 MPSA56	f_T	 100 50	 — —	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 — SWITCHING TIME TEST CIRCUITS



*Total Shunt Capacitance of Test Jig and Connectors
For PNP Test Circuits, Reverse All Voltage Polarities

FIGURE 2 — CURRENT-GAIN—BANDWIDTH PRODUCT

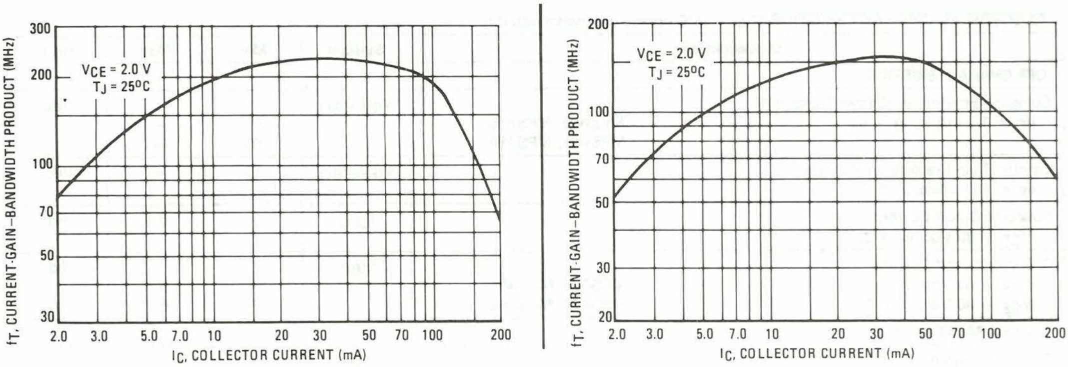


FIGURE 3 — CAPACITANCE

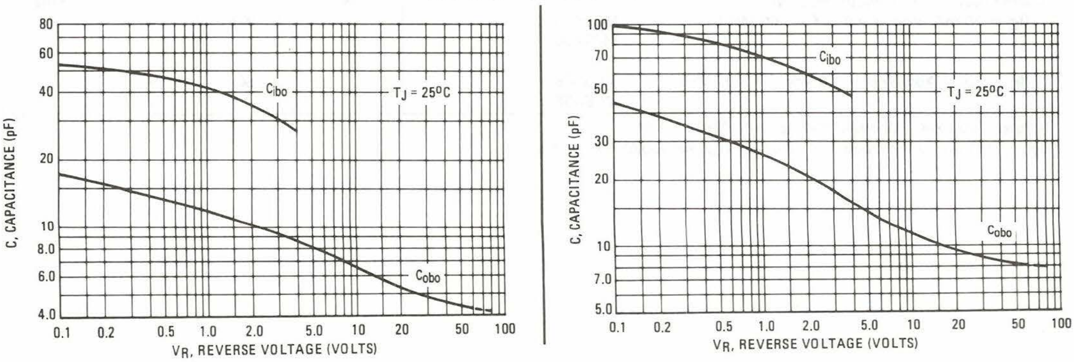


FIGURE 4 – SWITCHING TIME

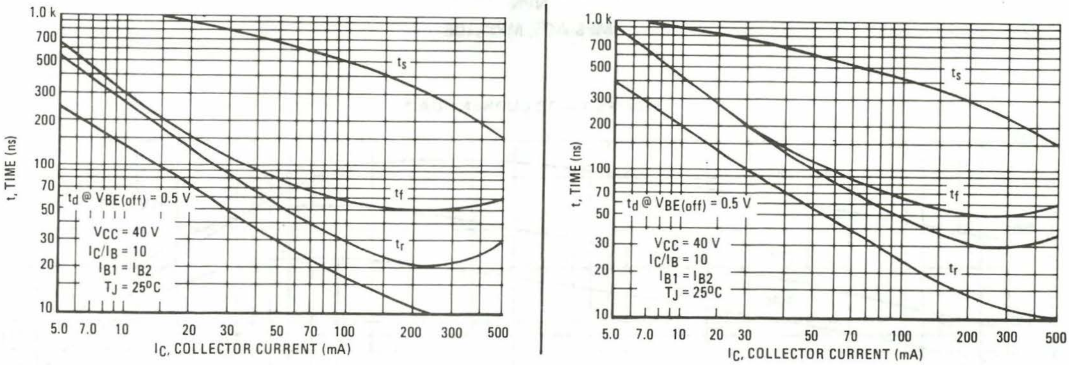


FIGURE 5 – THERMAL RESPONSE

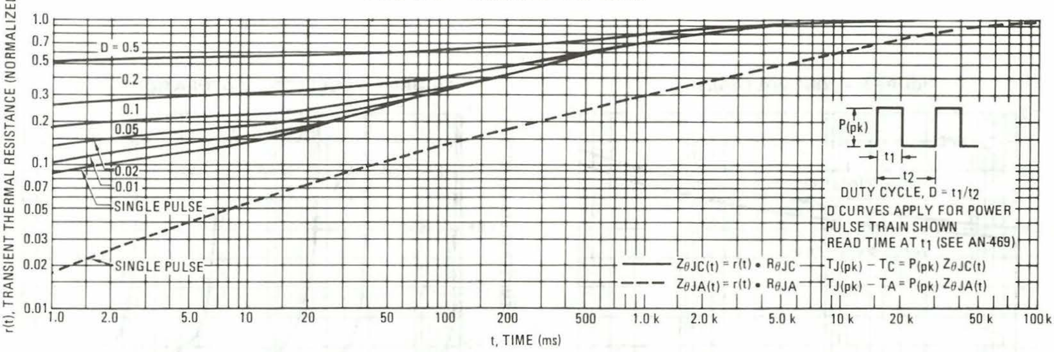
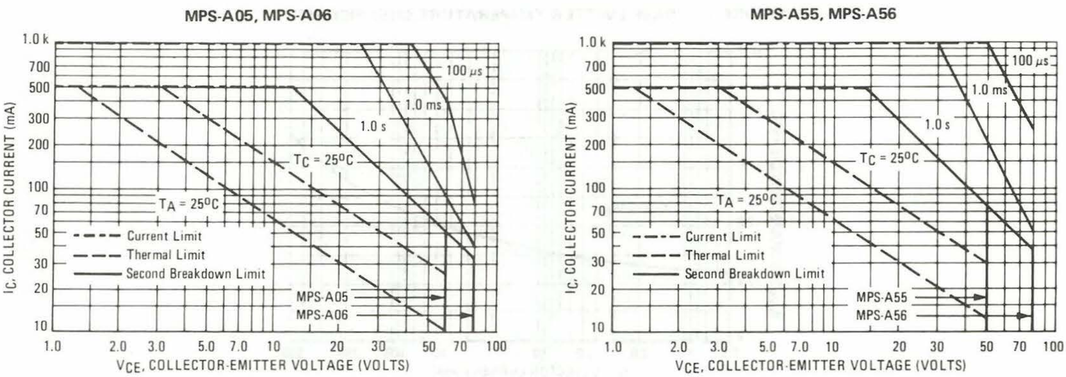


FIGURE 6 – ACTIVE – REGION SAFE OPERATING AREA



2

NPN
MPS-A05, MPS-A06

FIGURE 7 — DC CURRENT GAIN

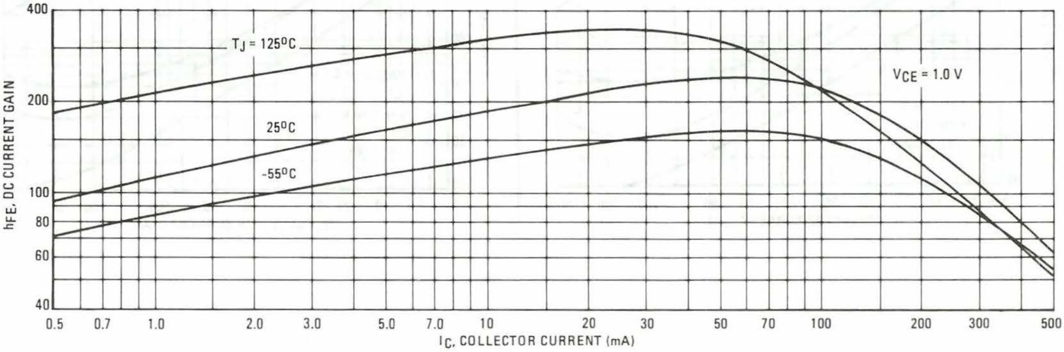


FIGURE 8 — "ON" VOLTAGES

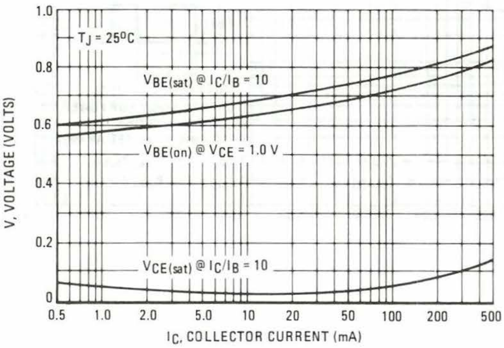


FIGURE 9 — COLLECTOR SATURATION REGION

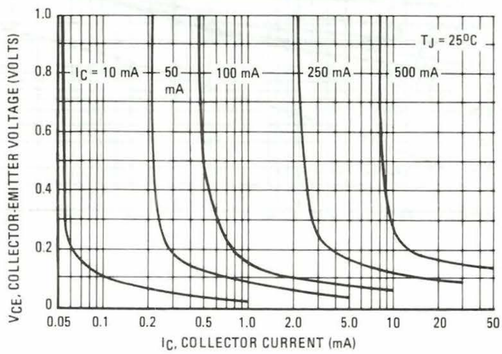
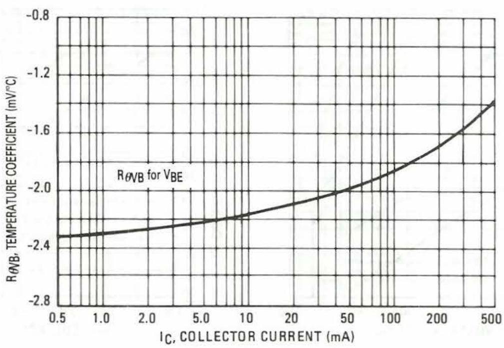


FIGURE 10 — BASE-EMITTER TEMPERATURE COEFFICIENT



PNP
MPS-A55, MPS-A56

FIGURE 11 — DC CURRENT GAIN

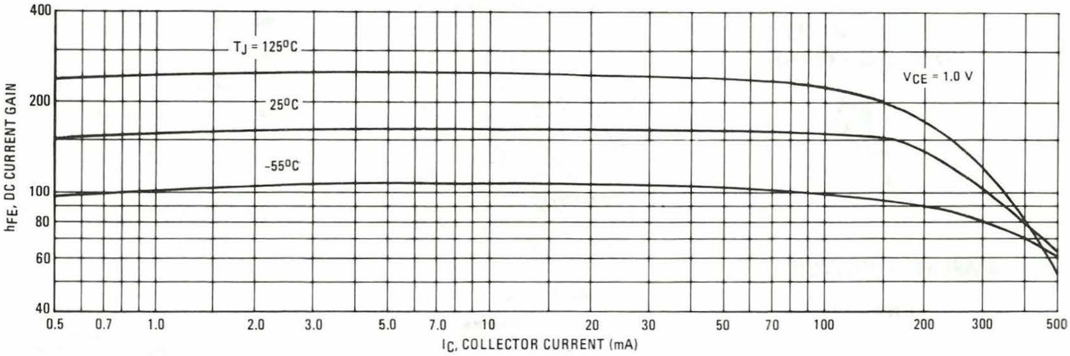


FIGURE 12 — "ON" VOLTAGES

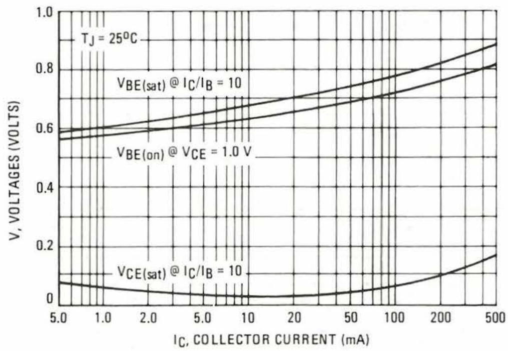


FIGURE 13 — COLLECTOR SATURATION REGION

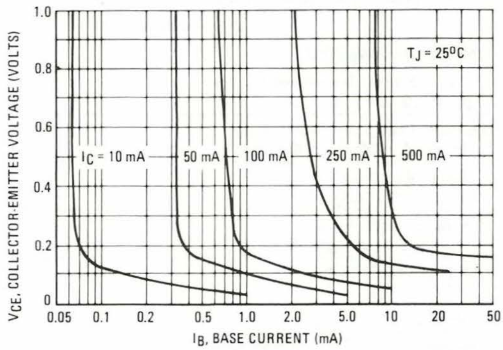
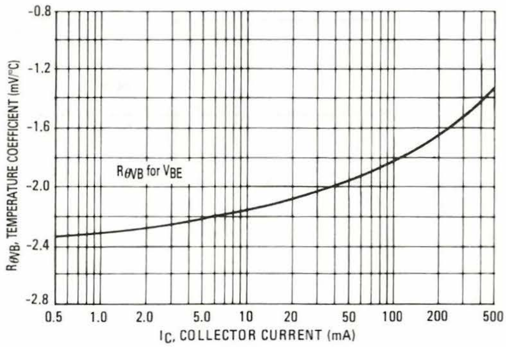


FIGURE 14 — BASE-EMITTER TEMPERATURE COEFFICIENT



MPSA09

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CBO}	50	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

Refer to MPSA18 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	50	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	50	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	—	100	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	100	—	600	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	—	0.9	Vdc
Base-Emitter On Voltage ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)	$V_{BE(on)}$	—	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 0.5$ mAdc, $V_{CE} = 5.0$ Vdc, f = 20 MHz)	f_T	30	80	—	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	—	5.0	pF
Noise Figure ($I_C = 0.1$ mAdc, $V_{CE} = 5.0$ Vdc, $R_S = 0.8$ k ohms, f = 1.0 kHz)	NF	—	1.4	—	dB

MPSA10

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MPS3903 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	40	400	—
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	125	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	4.0	pF

MPSA12

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

DARLINGTON TRANSISTOR

NPN SILICON

Refer to 2N6426 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	20	Vdc
Emitter-Base Voltage	V_{EBO}	10	Vdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu Adc$, $I_B = 0$)	$V_{(BR)CES}$	20	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	—	100	nAdc
Collector Cutoff Current ($V_{CE} = 15$ Vdc, $V_{BE} = 0$)	I_{CES}	—	—	100	nAdc
Emitter Cutoff Current ($V_{EB} = 10$ Vdc, $I_C = 0$)	I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	20,000	—	—	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 0.01$ mAdc)	$V_{CE(sat)}$	—	—	1.0	Vdc
Base-Emitter On Voltage ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	V_{BE}	—	—	1.4	Vdc

MPSA13
MPSA14

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

DARLINGTON TRANSISTOR

NPN SILICON

Refer to 2N6426 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	10	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

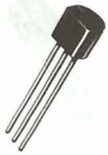
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu Adc$, $I_B = 0$)		$V_{(BR)CES}$	30	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{BE} = 10$ Vdc, $I_C = 0$)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	 MPSA13 MPSA14	h_{FE}	 5000 10,000	 — —	—
($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)	MPSA13 MPSA14		10,000 20,000	— —	
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 0.1$ mAdc)		$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)		V_{BE}	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)		f_T	125	—	MHz

(1) Pulse Test: Pulse Width $\leq 300\ \mu s$, Duty Cycle $\leq 2.0\%$.
(2) $f_T = |h_{fe}| \cdot f_{test}$.

MPSA16
MPSA17

CASE 29-02, STYLE 1
TO-92 (TO-226AA)



SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MPS-A16	MPS-A17	Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	12	15	Vdc
Collector Current — Continuous	I_C	100		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	MPS-A16 MPS-A17	$V_{(BR)EBO}$	12 15	— —	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{BE} = 10$ Vdc, $I_C = 0$)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc)		h_{FE}	200	600	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)		$V_{CE(sat)}$	—	0.25	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	MPS-A16 MPS-A17	f_T	100 80	— —	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)		C_{obo}	—	4.0	pF

FIGURE 1 – DC CURRENT GAIN

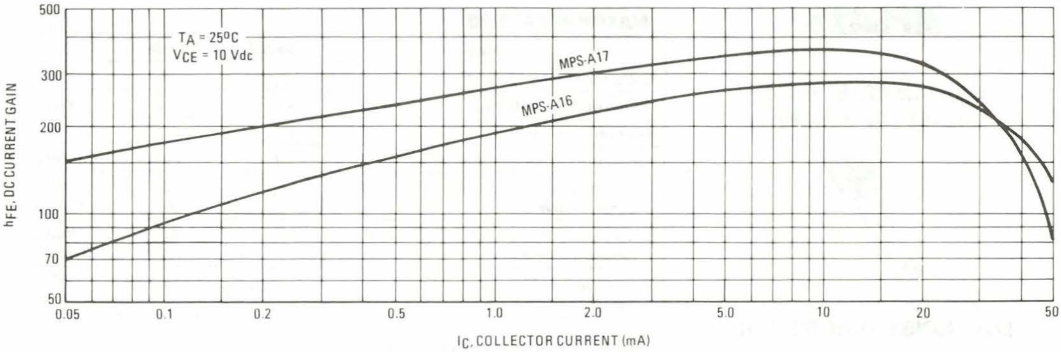


FIGURE 2 – SMALL SIGNAL CURRENT GAIN

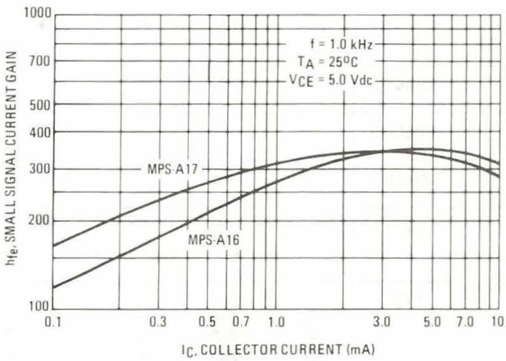


FIGURE 3 – SATURATION AND ON VOLTAGES

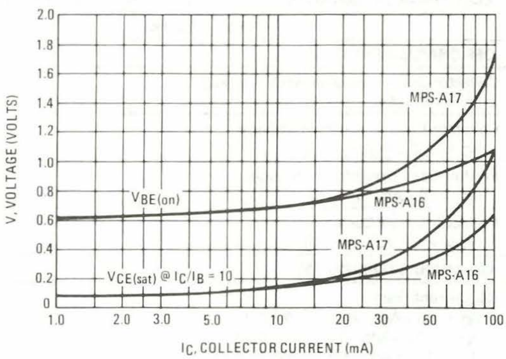


FIGURE 4 – CURRENT-GAIN–BANDWIDTH PRODUCT

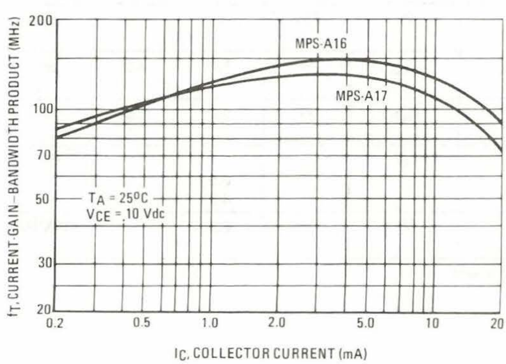
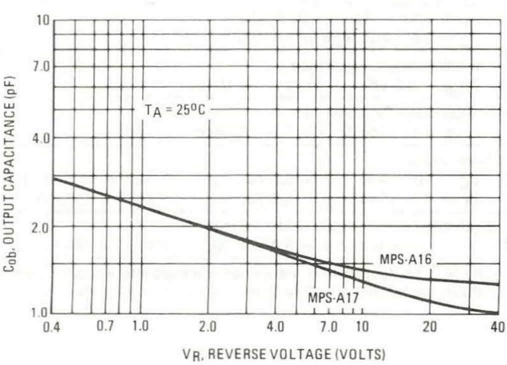


FIGURE 5 – OUTPUT CAPACITANCE



2

MPSA18

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

LOW NOISE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CBO}	45	Vdc
Emitter-Base Voltage	V_{EBO}	6.5	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

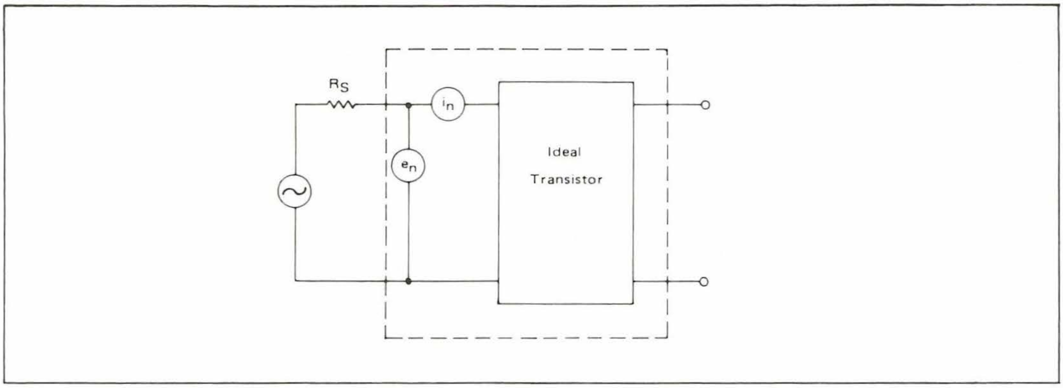
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	45	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	45	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	6.5	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	1.0	50	nAdc
ON CHARACTERISTICS(2)					
DC Current Gain ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	 400 500 500 500	 580 850 1100 1150	 — — — 1500	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 0.5$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{CE(sat)}$	 — —	 — 0.08	 0.2 0.3	Vdc
Base-Emitter On Voltage ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)	$V_{BE(on)}$	—	0.6	0.7	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)	f_T	100	160	—	MHz
Collector-Base Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	—	1.7	3.0	pF
Emitter-Base Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)	C_{eb}	—	5.6	6.5	pF
Noise Figure ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ kΩ, f = 10 Hz to 15.7 kHz) ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc, $R_S = 1.0$ kΩ, f = 100 Hz)	NF	 — —	 0.5 4.0	 1.5 —	dB
Equivalent Short Circuit Noise Voltage ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc, $R_S = 1.0$ kΩ, f = 100 Hz)	V_T	—	6.5	—	nV/$\sqrt{Hz}$

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – TRANSISTOR NOISE MODEL



NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

NOISE VOLTAGE

FIGURE 2 – EFFECTS OF FREQUENCY

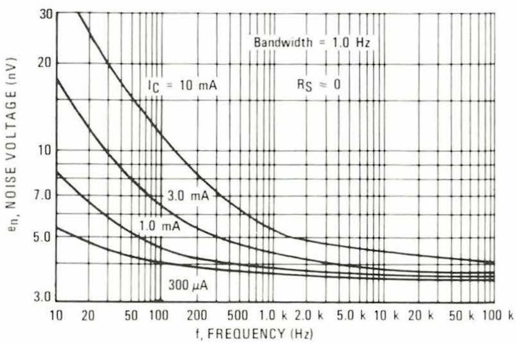


FIGURE 3 – EFFECTS OF COLLECTOR CURRENT

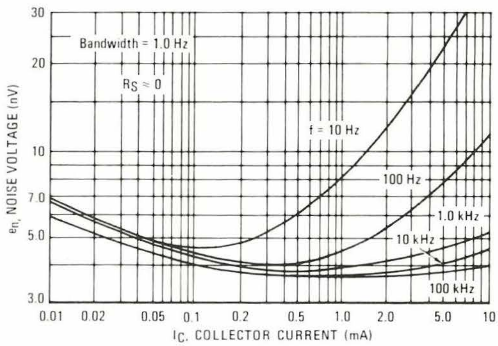


FIGURE 4 – NOISE CURRENT

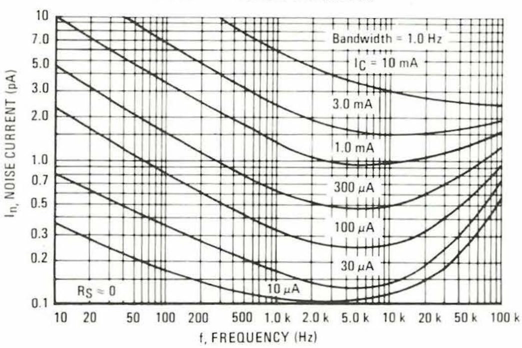
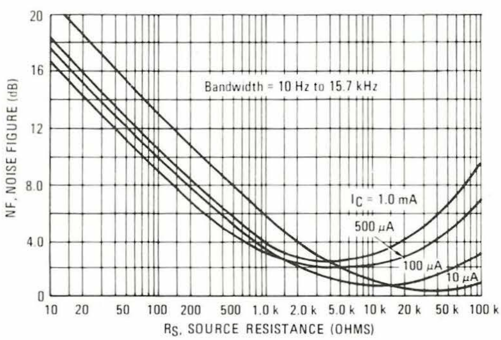


FIGURE 5 – WIDEBAND NOISE FIGURE



100 Hz NOISE DATA

FIGURE 6 – TOTAL NOISE VOLTAGE

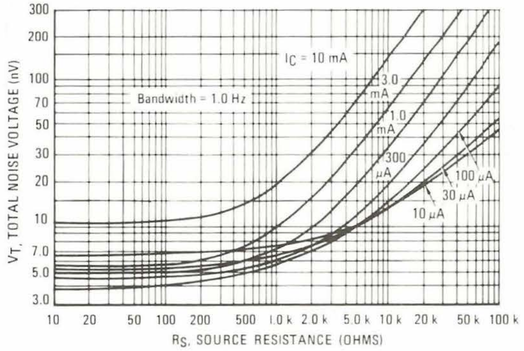


FIGURE 7 – NOISE FIGURE

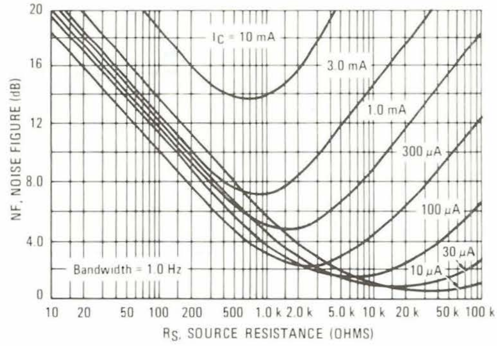


FIGURE 8 — DC CURRENT GAIN

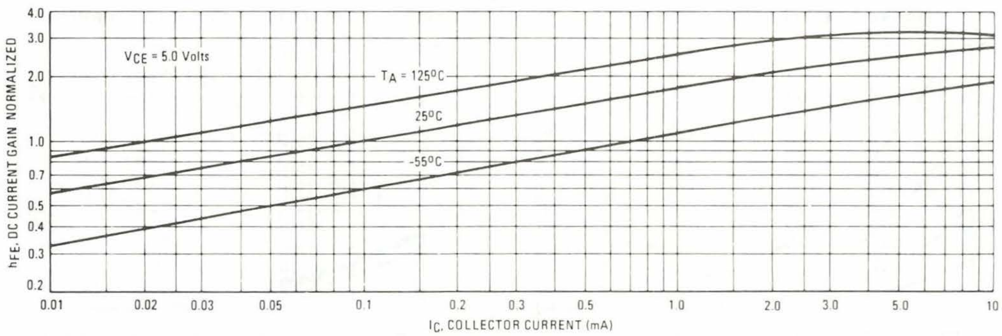


FIGURE 9 – "ON" VOLTAGES

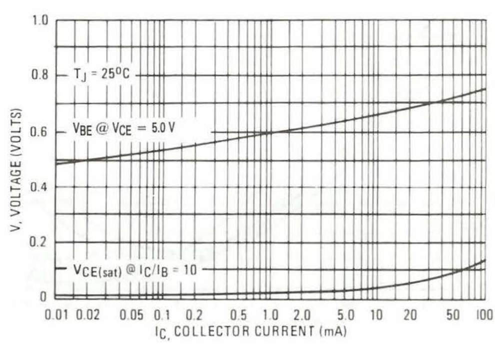


FIGURE 10 – TEMPERATURE COEFFICIENTS

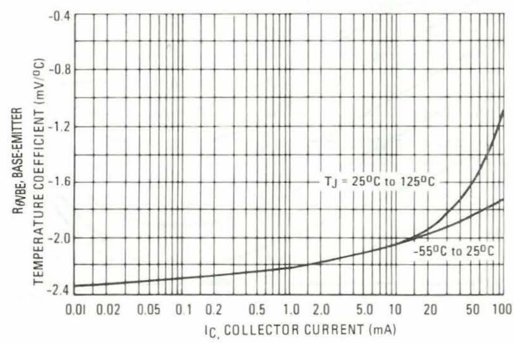


FIGURE 11 – CAPACITANCE

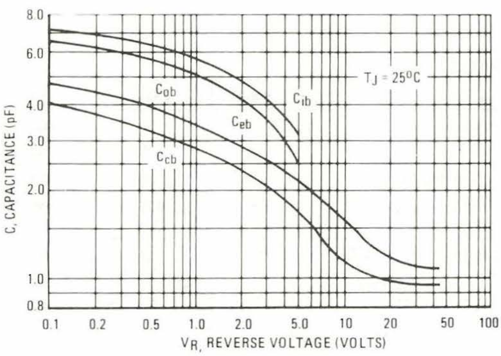
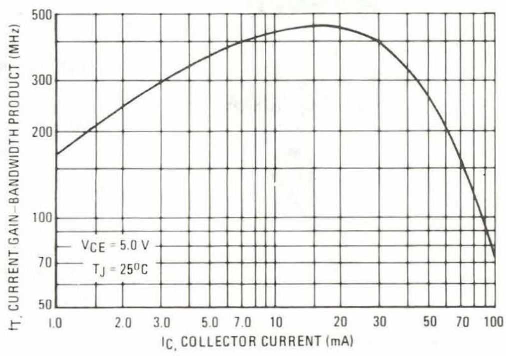


FIGURE 12 – CURRENT-GAIN–BANDWIDTH PRODUCT



2

MPSA20

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MPS3903 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(2) ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain(2) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	40	400	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(2) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz	f_T	125	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	4.0	pF

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width $\leq 300\ \mu s$, Duty Cycle $\leq 2.0\%$.

MPSA25
MPSA26
MPSA27

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

DARLINGTON TRANSISTOR

NPN SILICON

2

MAXIMUM RATINGS

Rating	Symbol	MPS-A25	MPS-A26	MPS-A27	Unit
Collector-Emitter Voltage	V_{CES}	40	50	60	Vdc
Emitter-Base Voltage	V_{EBO}		10		Vdc
Collector Current — Continuous	I_C		500		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D		625 5.0		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu Adc$, $V_{BE} = 0$)	MPSA25 MPSA26 MPSA27	$V_{(BR)CES}$	40 50 60	— — —	— — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu Adc$, $I_E = 0$)	MPSA25 MPSA26 MPSA27	$V_{(BR)CBO}$	40 50 60	— — —	— — —	Vdc
Collector Cutoff Current ($V_{CB} = 30$ V, $I_E = 0$) ($V_{CB} = 40$ V, $I_E = 0$) ($V_{CB} = 50$ V, $I_E = 0$)	MPSA25 MPSA26 MPSA27	I_{CBO}	— — —	— — —	100 100 100	nAdc
Collector Cutoff Current ($V_{CE} = 30$ V, $V_{BE} = 0$) ($V_{CE} = 40$ V, $V_{BE} = 0$) ($V_{CE} = 50$ V, $V_{BE} = 0$)	MPSA25 MPSA26 MPSA27	I_{CES}	— — —	— — —	500 500 500	nAdc
Emitter Cutoff Current ($V_{BE} = 10$ Vdc)		I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS(1)						
DC Current Gain ($I_C = 10$ mA, $V_{CE} = 5.0$ V) ($I_C = 100$ mA, $V_{CE} = 5.0$ V)		h_{FE}	10,000 10,000	— —	— —	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mA, $I_B = 0.1$ mAdc)		$V_{CE(sat)}$	—	—	1.5	Vdc
Base-Emitter On Voltage ($I_C = 100$ mA, $V_{CE} = 5.0$ Vdc)		$V_{BE(on)}$	—	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Small Signal Current Gain ($I_C = 10$ mA, $V_{CE} = 5.0$ V, f = 100 MHz)		h_{fe}	1.25	2.4	—	—

(1) Pulse Test: Pulse Width $\leq 300\ \mu s$, Duty Cycle $\leq 2.0\%$.

FIGURE 1 — DC CURRENT GAIN

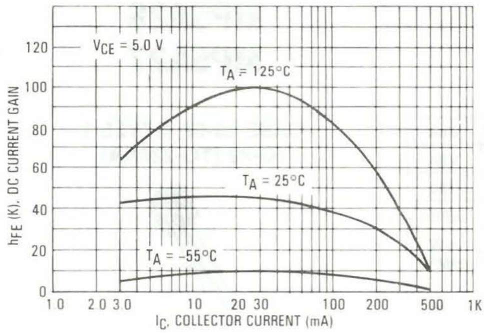


FIGURE 2 — "ON" VOLTAGES

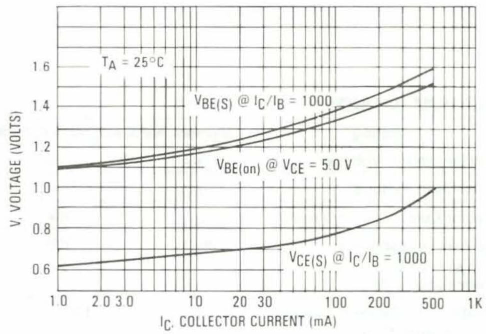


FIGURE 3 — COLLECTOR SATURATION REGION

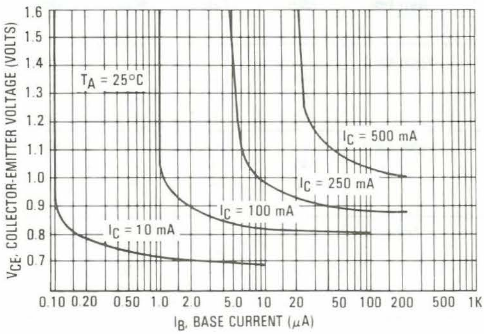


FIGURE 4 — HIGH FREQUENCY CURRENT GAIN

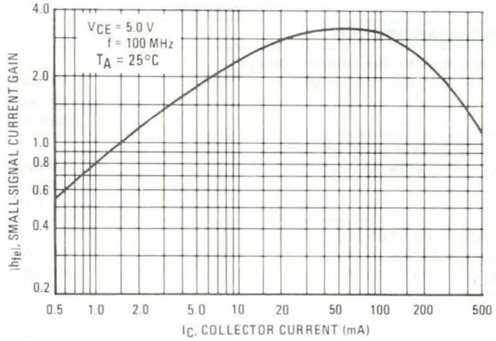
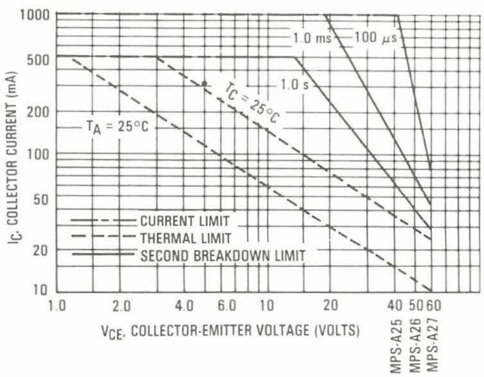


FIGURE 5 — ACTIVE REGION SAFE OPERATING AREA



MPSA28
MPSA29

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

DARLINGTON TRANSISTOR

NPN SILICON

2

MAXIMUM RATINGS

Rating	Symbol	MPSA28	MPSA29	Unit
Collector-Emitter Voltage	V_{CES}	80	100	Vdc
Collector-Base Voltage	V_{CBO}	80	100	Vdc
Emitter-Base Voltage	V_{EBO}	12		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu Adc$, $V_{BE} = 0$)	 MPSA28 MPSA29	$V_{(BR)CES}$	 80 100	 — —	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu Adc$, $I_E = 0$)	 MPSA28 MPSA29	$V_{(BR)CBO}$	 80 100	 — —	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu Adc$, $I_C = 0$)	 Both Types	$V_{(BR)EBO}$	12	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 80$ Vdc, $I_E = 0$)	 MPSA28 MPSA29	I_{CBO}	 — —	 — —	 100 100	nAdc
Collector Cutoff Current ($V_{CE} = 60$ Vdc, $V_{BE} = 0$) ($V_{CE} = 80$ Vdc, $V_{BE} = 0$)	 MPSA28 MPSA29	I_{CES}	 — —	 — —	 500 500	nAdc
Emitter Cutoff Current ($V_{BE} = 10$ Vdc, $I_C = 0$)	 Both Types	I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS(1)						
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)	 Both Types Both Types	h_{FE}	 10,000 10,000	 — —	 — —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 0.01$ mAdc) ($I_C = 100$ mAdc, $I_B = 0.1$ mAdc)	 Both Types Both Types	$V_{CE(sat)}$	 — —	 0.7 0.8	 1.2 1.5	Vdc
Base-Emitter On Voltage ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)	 Both Types	$V_{BE(on)}$	—	1.4	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(2) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)	 Both Types	f_T	125	200	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	 Both Types	C_{obo}	—	5.0	8.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = h_{fe} \cdot f_{test}$.

FIGURE 1 — DC CURRENT GAIN

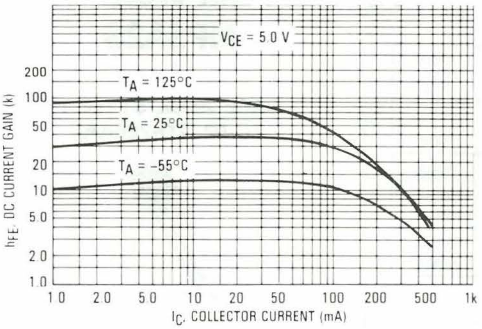


FIGURE 2 — ON VOLTAGES

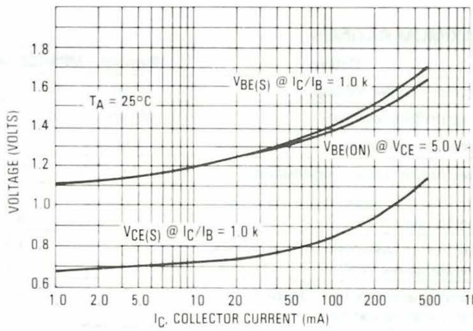


FIGURE 3 — TEMPERATURE COEFFICIENTS

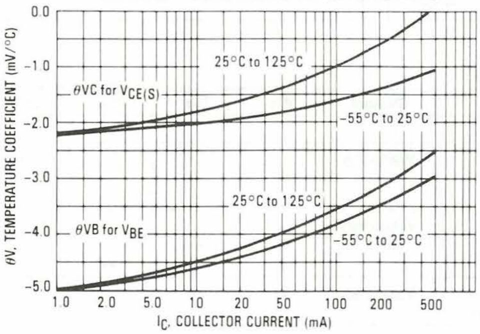


FIGURE 4 — COLLECTOR SATURATION REGION

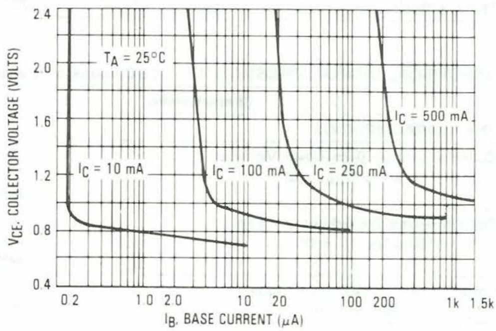


FIGURE 5 — ACTIVE REGION — SAFE OPERATING AREA

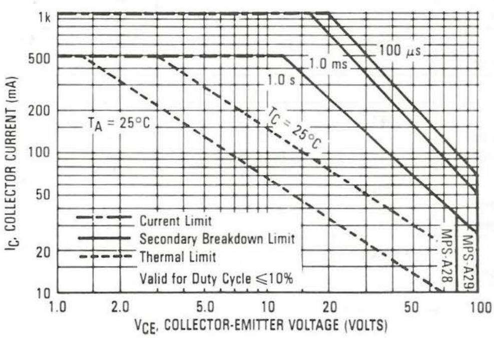
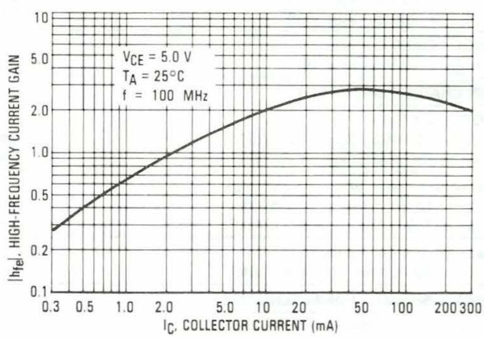


FIGURE 6 — HIGH FREQUENCY CURRENT GAIN



MPSA42
MPSA43

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTOR

NPN SILICON

2

MAXIMUM RATINGS

Rating	Symbol	MPSA42	MPSA43	Unit
Collector-Emitter Voltage	V_{CEO}	300	200	Vdc
Collector-Base Voltage	V_{CBO}	300	200	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	6.0	Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	 MPSA42 MPSA43	$V_{(BR)CEO}$	 300 200	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	 MPSA42 MPSA43	$V_{(BR)CBO}$	 300 200	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 200$ Vdc, $I_E = 0$) ($V_{CB} = 160$ Vdc, $I_E = 0$)	 MPSA42 MPSA43	I_{CBO}	 — —	 0.1 0.1	μAdc
Emitter Cutoff Current ($V_{BE} = 6.0$ Vdc, $I_C = 0$) ($V_{BE} = 4.0$ Vdc, $I_C = 0$)	 MPSA42 MPSA43	I_{EBO}	 — —	 0.1 0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)	 Both Types Both Types MPSA42 MPSA43	h_{FE}	 25 40 40 40	 — — —	—
Collector-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)	 MPSA42 MPSA43	$V_{CE(sat)}$	 — —	 0.5 0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)		f_T	50	—	MHz
Collector-Base Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 1.0 MHz)	 MPSA42 MPSA43	C_{cb}	 — —	 3.0 4.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – DC CURRENT GAIN

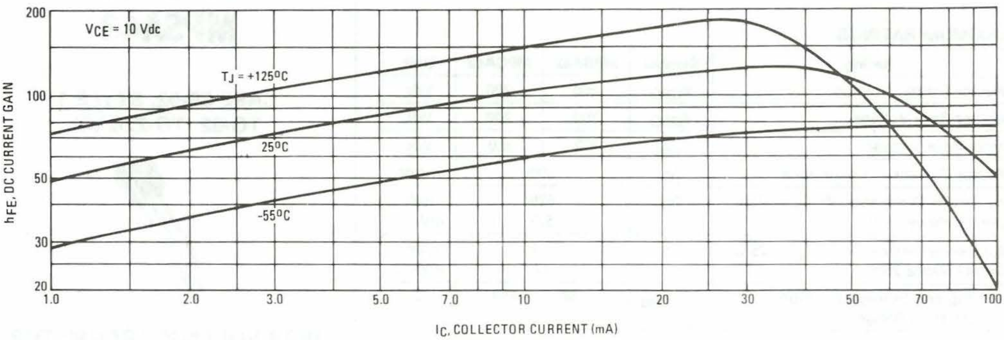


FIGURE 2 – CAPACITANCES

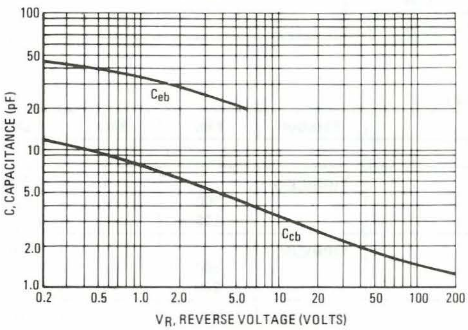


FIGURE 3 – CURRENT-GAIN–BANDWIDTH PRODUCT

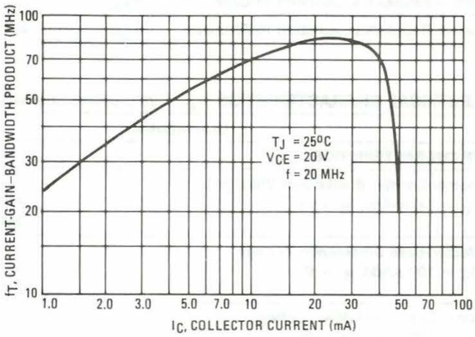


FIGURE 4 – "ON" VOLTAGES

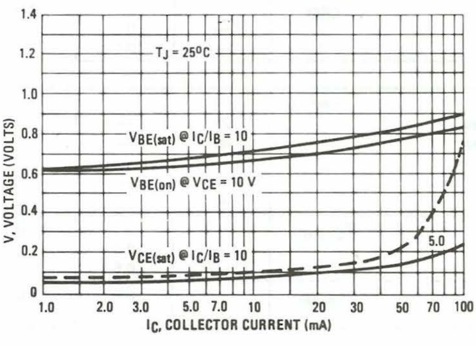
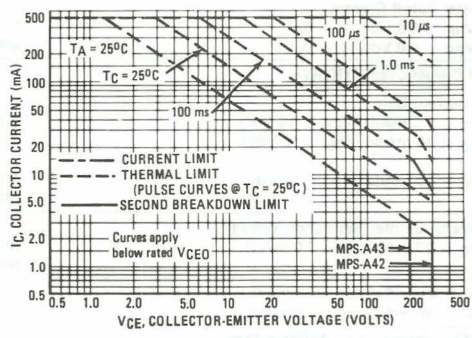


FIGURE 5 – MAXIMUM FORWARD BIAS SAFE OPERATING AREA



MPSA44
MPSA45

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MPSA44	MPSA45	Unit
Collector-Emitter Voltage	V_{CEO}	400	350	Vdc
Collector-Base Voltage	V_{CBO}	500	400	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	6.0	Vdc
Collector Current — Continuous	I_C	300		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	 MPSA44 MPSA45	$V_{(BR)CEO}$	 400 350	 — —	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100$ μAdc, $V_{BE} = 0$)	 MPSA44 MPSA45	$V_{(BR)CES}$	 500 400	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	 MPSA44 MPSA45	$V_{(BR)CBO}$	 500 400	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 400$ Vdc, $I_E = 0$) ($V_{CB} = 320$ Vdc, $I_E = 0$)	 MPSA44 MPSA45	I_{CBO}	 — —	 0.1 0.1	μAdc
Collector Cutoff Current ($V_{CE} = 400$ Vdc, $V_{BE} = 0$) ($V_{CE} = 320$ Vdc, $V_{BE} = 0$)	 MPSA44 MPSA45	I_{CES}	 — —	 500 500	nAdc
Emitter Cutoff Current ($V_{BE} = 4.0$ Vdc, $I_C = 0$)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain(1) ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 10$ Vdc)		h_{FE}	40 50 45 40	— 200 — —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0.1$ mAdc) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{CE(sat)}$	— — —	0.4 0.5 0.75	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)		$V_{BE(sat)}$	—	0.75	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	7.0	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)		C_{ibo}	—	13	pF
Small-Signal Current Gain ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 10 MHz)		h_{fe}	2.0	—	—

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPSA55, MPSA56

For Specifications, See MPSA05

2

FIGURE 1 — DC CURRENT GAIN

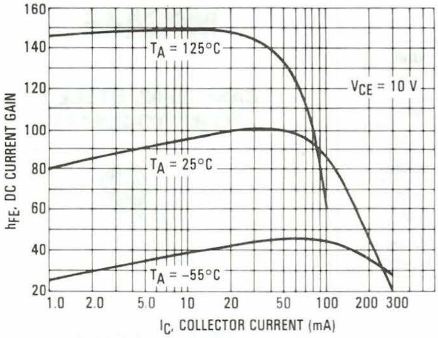


FIGURE 2 — COLLECTOR SATURATION REGION

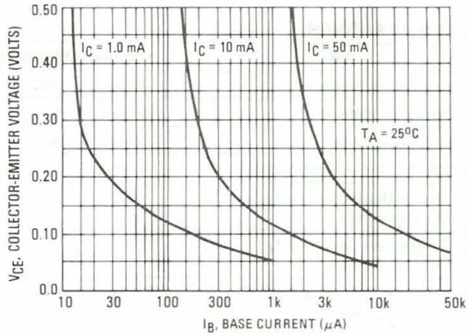


FIGURE 3 — ON VOLTAGES

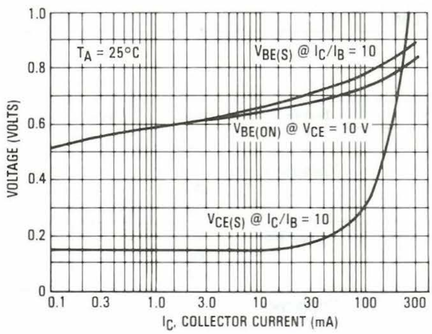


FIGURE 4 — ACTIVE REGION — SAFE OPERATING AREA

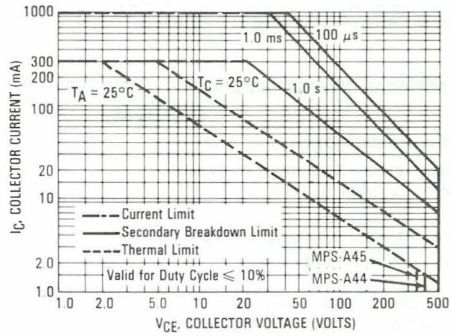


FIGURE 5 — CAPACITANCE

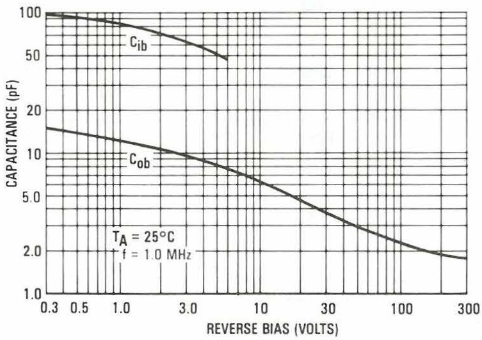
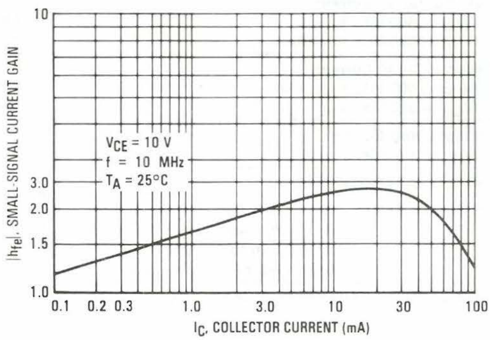
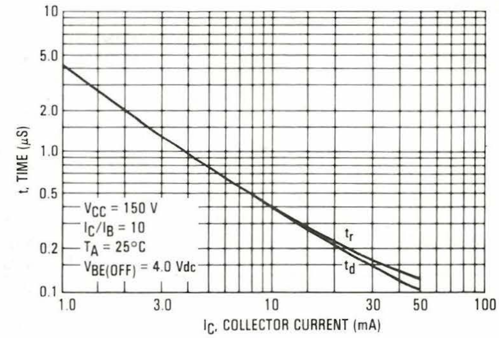


FIGURE 6 — HIGH FREQUENCY CURRENT GAIN



2

FIGURE 7 — TURN-ON SWITCHING TIMES AND TEST CIRCUIT



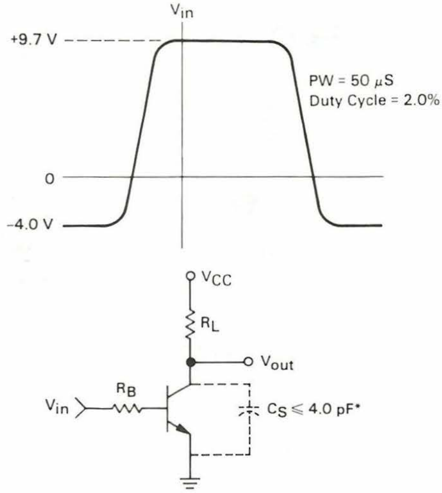
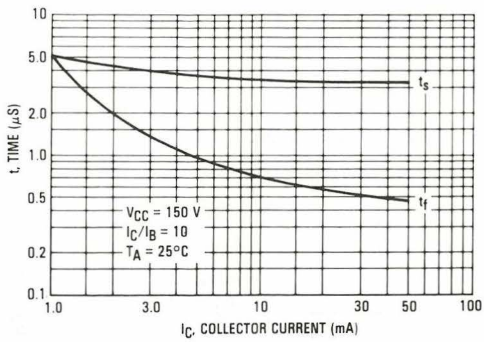
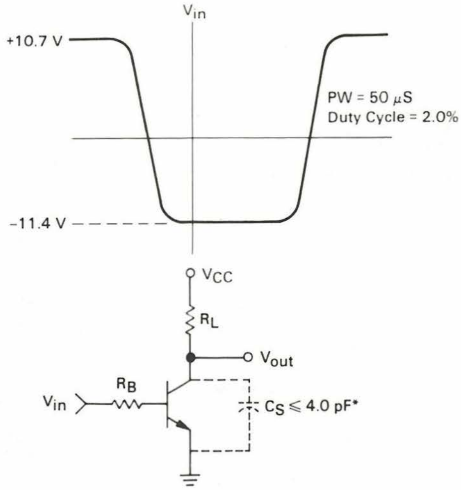


FIGURE 8 — TURN-OFF SWITCHING TIMES AND TEST CIRCUIT





*Total Shunt Capacitance or Test Jig and Connectors.

MPSA62
MPSA63
MPSA64

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

DARLINGTON TRANSISTOR

PNP SILICON

Refer to MPSA75 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPSA62	MPSA63 MPSA64	Unit
Collector-Emitter Voltage	V_{CES}	20	30	Vdc
Collector-Base Voltage	V_{CBO}	20	30	Vdc
Emitter-Base Voltage	V_{EBO}	10		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu Adc$, $V_{BE} = 0$)	 MPSA62 MPSA63, MPSA64	$V_{(BR)CES}$	 20 30	 — —	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$) ($V_{CB} = 30$ Vdc, $I_E = 0$)	 MPSA62 MPSA63, MPSA64	I_{CBO}	 — —	 100 100	nAdc
Emitter Cutoff Current ($V_{BE} = 10$ Vdc, $I_C = 0$)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)	 MPSA63 MPSA64 MPSA62 MPSA63 MPSA64	h_{FE}	 5000 10,000 20,000 10,000 20,000	 — — — — —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 0.01$ mAdc) ($I_C = 100$ mAdc, $I_B = 0.1$ mAdc)	 MPSA62 MPSA63, MPSA64	$V_{CE(sat)}$	 — —	 1.0 1.5	Vdc
Base-Emitter On Voltage ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)	 MPSA62 MPSA63, MPSA64	$V_{BE(on)}$	 — —	 1.4 2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)	 MPSA63, MPSA64	f_T	125	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$.

MPSA70

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N5086 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	40	100	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	125	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	4.0	pF

2

MPSA75
MPSA76
MPSA77

CASE 29-02
TO-92 (TO-226AA)

DARLINGTON TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MPSA75	MPSA76	MPSA77	Unit
Collector-Emitter Voltage	V_{CES}	40	50	60	Vdc
Emitter-Base Voltage	V_{EBO}		10		Vdc
Collector Current — Continuous	I_C		500		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D		625 5.0		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu Adc$, $V_{BE} = 0$)	MPSA75 MPSA76 MPSA77	$V_{(BR)CES}$	40 50 60	— — —	— — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu Adc$, $I_E = 0$)	MPSA75 MPSA76 MPSA77	$V_{(BR)CBO}$	40 50 60	— — —	— — —	Vdc
Collector Cutoff Current ($V_{CB} = 30$ V, $I_E = 0$) ($V_{CB} = 40$ V, $I_E = 0$) ($V_{CB} = 50$ V, $I_E = 0$)	MPSA75 MPSA76 MPSA77	I_{CBO}	— — —	— — —	100 100 100	nAdc
Collector Cutoff Current ($V_{CE} = 30$ V, $V_{BE} = 0$) ($V_{CE} = 40$ V, $V_{BE} = 0$) ($V_{CE} = 50$ V, $V_{BE} = 0$)	MPSA75 MPSA76 MPSA77	I_{CES}	— — —	— — —	500 500 500	nAdc
Emitter Cutoff Current ($V_{BE} = 10$ Vdc)		I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = 10$ mA, $V_{CE} = 5.0$ V) ($I_C = 100$ mA, $V_{CE} = 5.0$ V)		h_{FE}	10,000 10,000	— —	— —	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mA, $I_B = 0.1$ mAdc)		$V_{CE(sat)}$	—	—	1.5	Vdc
Base-Emitter On Voltage ($I_C = 100$ mA, $V_{CE} = 5.0$ Vdc)		V_{BE}	—	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current Gain — High Frequency ($I_C = 10$ mA, $V_{CE} = 5.0$ V, f = 100 MHz)		$\|h_{fe}\|$	1.25	2.4	—	—

FIGURE 1 — DC CURRENT GAIN

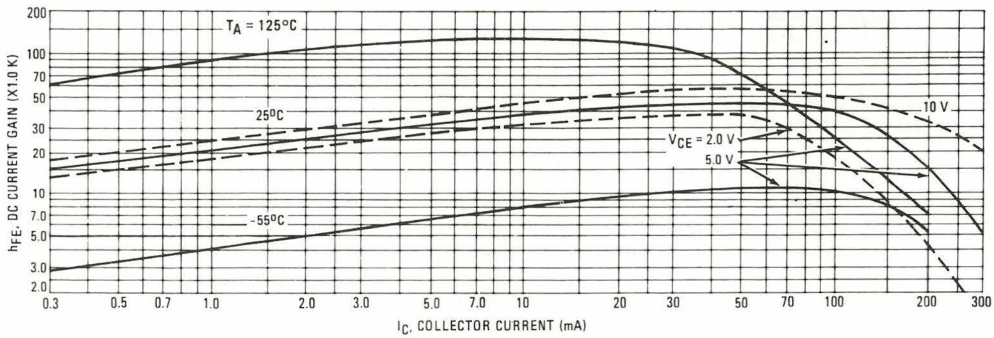


FIGURE 2 — "ON" VOLTAGE

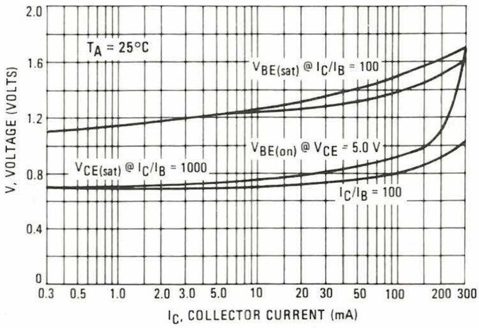


FIGURE 3 — COLLECTOR SATURATION REGION

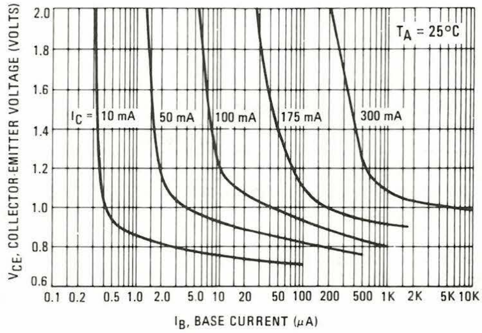


FIGURE 4 — HIGH FREQUENCY CURRENT GAIN

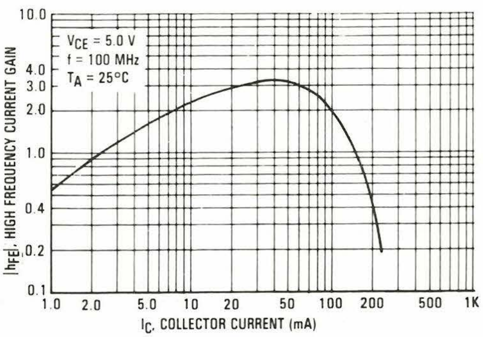
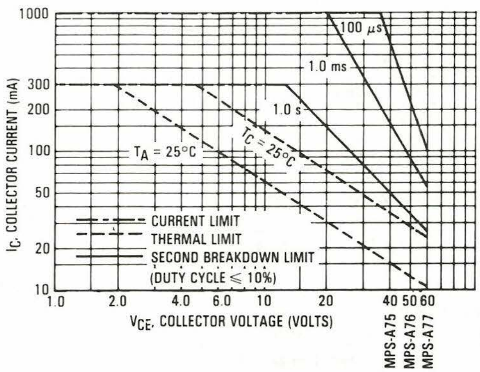


FIGURE 5 — ACTIVE REGION, SAFE OPERATING AREA



MPSA92
MPSA93

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

HIGH VOLTAGE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MPS-A92	MPS-A93	Unit
Collector-Emitter Voltage	V_{CEO}	300	200	Vdc
Collector-Base Voltage	V_{CBO}	300	200	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	MPSA92 MPSA93	$V_{(BR)CEO}$	300 200	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	MPSA92 MPSA93	$V_{(BR)CBO}$	300 200	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 200$ Vdc, $I_E = 0$) ($V_{CB} = 160$ Vdc, $I_E = 0$)	MPSA92 MPSA93	I_{CBO}	— —	0.25 0.25	μAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)	Both Types Both Types MPSA92 MPSA93	h_{FE}	25 40 25 25	— — — —	—
Collector-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)	MPSA92 MPSA93	$V_{CE(sat)}$	— —	0.5 0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)		f_T	50	—	MHz
Collector-Base Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 1.0 MHz)	MPSA92 MPSA93	C_{cb}	— —	6.0 8.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

FIGURE 1 – DC CURRENT GAIN

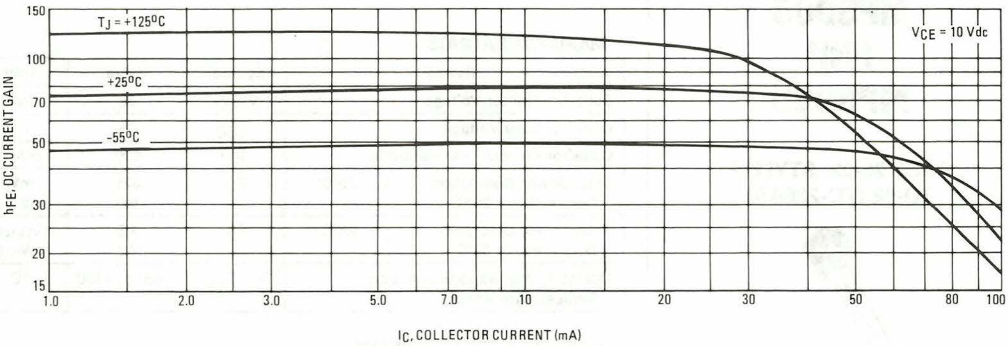


FIGURE 2 – CAPACITANCES

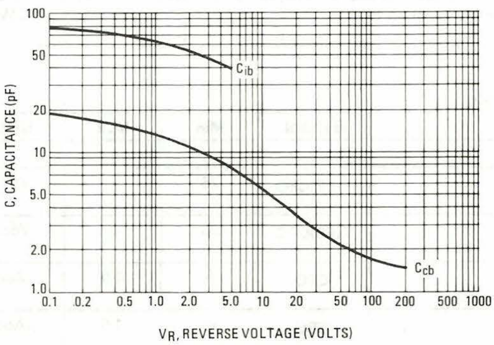


FIGURE 3 – CURRENT-GAIN–BANDWIDTH PRODUCT

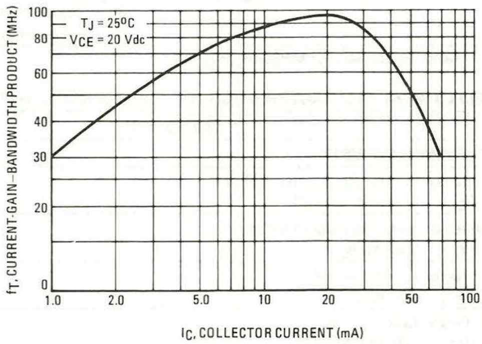


FIGURE 4 – "ON" VOLTAGES

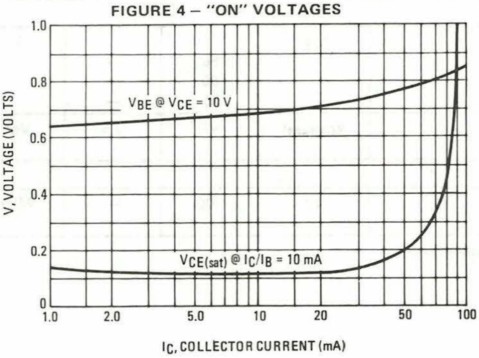
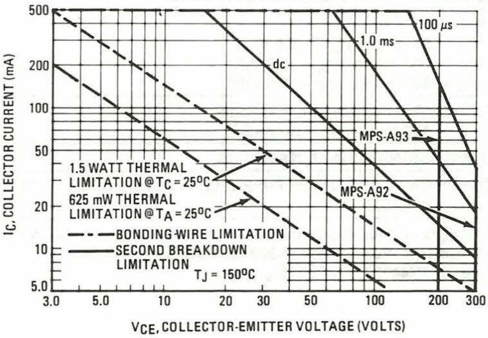


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



NPN MPSD05 PNP MPSD55

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

Refer to 2N4400 for MPSD05 graphs.*

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Collector Current — Continuous	I_C	600	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient(1)	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	25	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	25	—	Vdc
Collector Cutoff Current ($V_{CE} = 20$ Vdc)	I_{CEO}	—	1.0	μAdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)	I_{CBO}	—	1.0	μAdc
Emitter Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(2)				
DC Current Gain ($I_C = 50$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 500$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	 50 80 30	 — — —	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 10$ mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	100	—	MHz

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
*Refer to 2N4402 for MPSD55 graphs.

MPSH02

CASE 29-02, STYLE 2
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	30	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/mW
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/mW

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	20	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	20	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 10$ Vdc, $I_E = 0$)	I_{CBO}	—	50	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	20	200	—
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	375	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	—	0.5	pF
Noise Figure ($V_{AGC} = 1.4$ Vdc, $R_S = 50$ Ohms, f = 200 MHz)	NF	—	3.3	dB
FUNCTIONAL TEST				
Amplifier Power Gain ($V_{AGC} = 1.4$ Vdc, $R_S = 50$ Ohms, f = 200 MHz)	G_{pe}	20	—	dB
Forward AGC Voltage (Gain Reduction = 30 dB, $R_S = 50$ Ohms, f = 200 MHz)	V_{AGC}	4.0	5.0	Vdc

AGC CHARACTERISTICS (V_{CC} = 12 Vdc, R_S = 50 Ohms, f = 200 MHz, See Figure 9)

FIGURE 1 – POWER GAIN

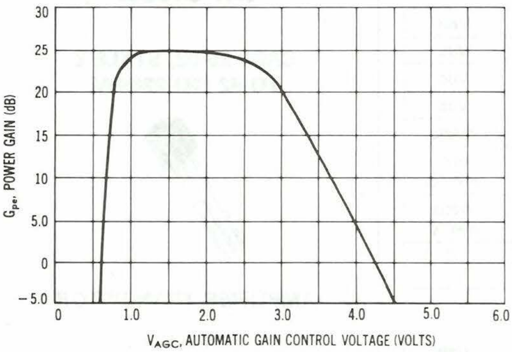
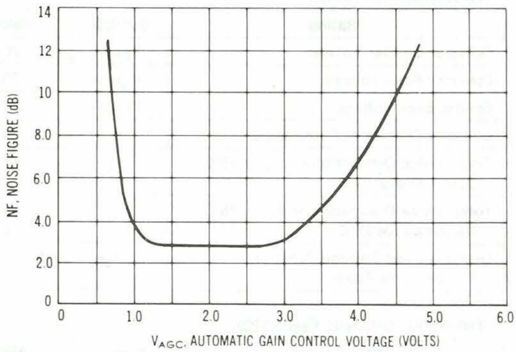


FIGURE 2 – NOISE FIGURE



COMMON-EMITTER y PARAMETERS (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 3 – INPUT ADMITTANCE

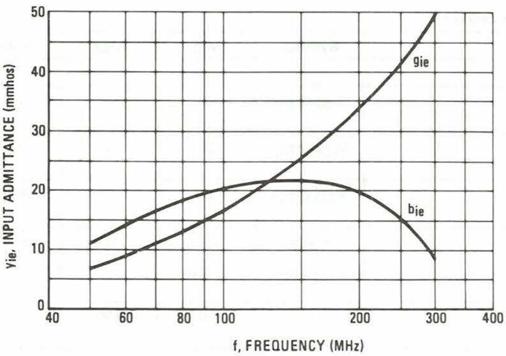
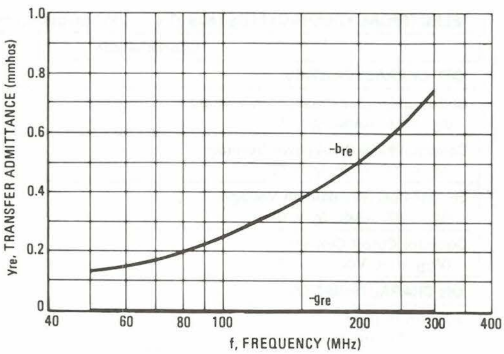


FIGURE 4 – REVERSE TRANSFER ADMITTANCE



COMMON-EMITTER y PARAMETERS
(I_C = 4.0 mAdc, V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 5 – FORWARD TRANSFER ADMITTANCE

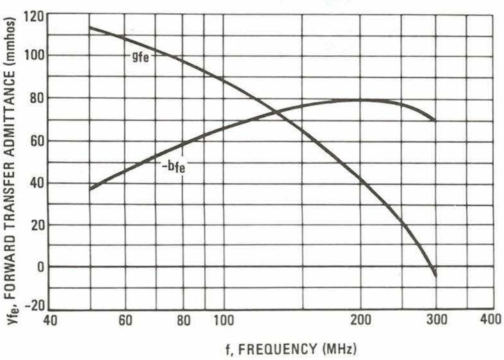
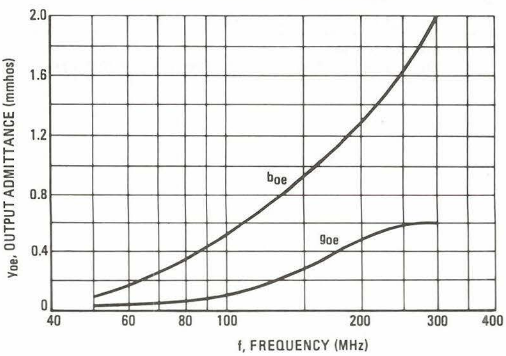


FIGURE 6 – OUTPUT ADMITTANCE



2

FIGURE 7 — DC CURRENT GAIN

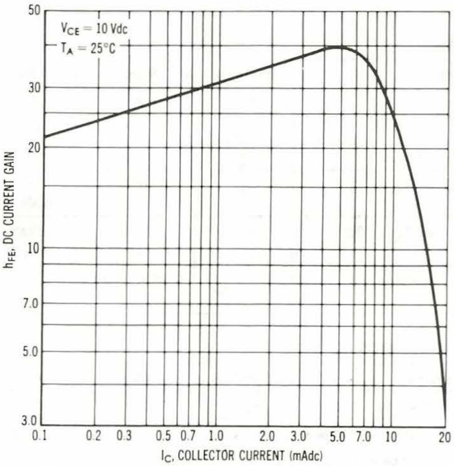


FIGURE 8 — COLLECTOR-BASE CAPACITANCE

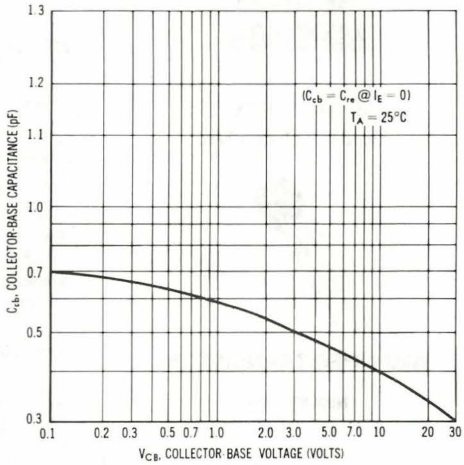
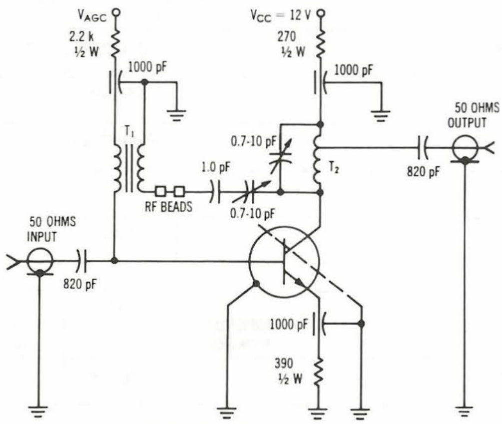


FIGURE 9 — 200 MHz FUNCTIONAL TEST CIRCUIT (NEUTRALIZED)



T1 = FERRITE CORE INDIANA GEN. CORP. F-684
T2 = 6 TURNS #16 BUSS WIRE, ID = ¼", L = ¾"

2

MPSH04
MPSH05

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) ($I_C = 1.0$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	80	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)		$V_{(BR)CBO}$	80	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$)		I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = 1.5$ mAdc, $V_{CE} = 10$ Vdc)	 MPSH04 MPSH05	h_{FE}	 30 30	 — —	 120 150	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)		$V_{CE(sat)}$	—	—	0.25	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Crrent-Gain — Bandwidth Product ($I_C = 1.5$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)		f_T	80	—	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, f = 1.0 MHz)		C_{cb}	—	—	1.6	pF
Output Admittance ($I_C = 1.5$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)		h_{oe}	—	—	5.0	μmhos
Noise Figure ($I_C = 1.5$ mAdc, $V_{CE} = 10$ Vdc, $R_S = 50$ ohms, f = 1.0 MHz)	MPSH04	NF	—	—	2.0	dB

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPSH07
MPSH08

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

FM/VHF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	350 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	357	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	30	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)		$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)		I_{CBO}	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 3.0$ mAdc, $V_{CE} = 10$ Vdc)		h_{FE}	20	—	—
Base-Emitter On Voltage ($I_C = 3.0$ mAdc, $V_{CE} = 10$ Vdc)		$V_{BE(on)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 3.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)		f_T	400	—	MHz
Collector-Emitter Capacitance ($V_{CE} = 10$ Vdc, $I_B = 0$, f = 1.0 MHz, base guarded)		C_{ce} (C_{rb})	—	0.3	pF
Noise Figure ($I_C = 3.0$ mAdc, $V_{CB} = 10$ Vdc, $R_S = 50$ Ohms, f = 100 MHz) ($I_C = 3.0$ mAdc, $V_{CB} = 10$ Vdc, $R_S = 50$ Ohms, f = 200 MHz)	 MPS-H07 MPS-H08	NF	 — —	 3.0 3.0	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain ($I_C = 3.0$ mAdc, $V_{CB} = 10$ Vdc, $R_S = 50$ Ohms, f = 100 MHz) ($I_C = 3.0$ mAdc, $V_{CB} = 10$ Vdc, $R_S = 50$ Ohms, f = 200 MHz)	 MPS-H07 MPS-H08	G_{pb}	 18 14	 — —	dB
Forward AGC Current (Gain Reduction = 30 dB, $R_S = 50$ Ohms, f = 100 MHz) (Gain Reduction = 30 dB, $R_S = 50$ Ohms, f = 200 MHz)	 MPS-H07 MPS-H08	I_{AGC}	 6.5 6.5	 8.5 8.5	mAdc

2

AGC CHARACTERISTICS

V_{CC} = 10 Vdc, R_S = 50 Ohms, See Figure 9

—— f = 100 MHz – – – f = 200 MHz

FIGURE 1 – POWER GAIN

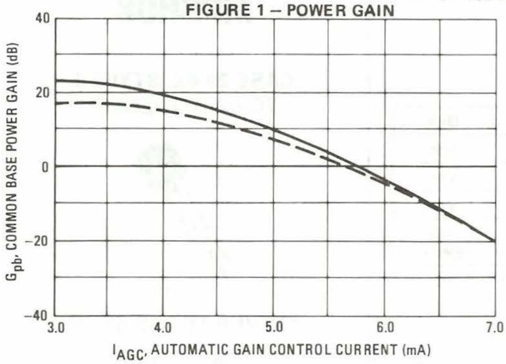
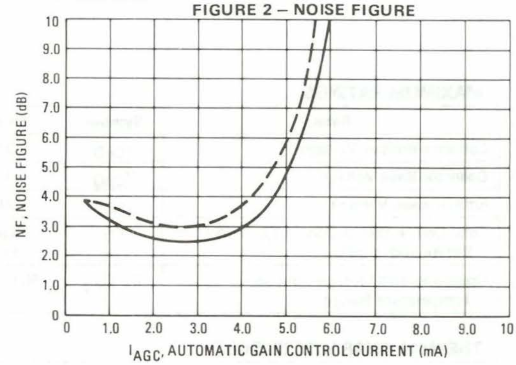


FIGURE 2 – NOISE FIGURE



COMMON-BASE y PARAMETERS

V_{CB} = 10 Vdc, T_A = 25°C

—— f = 100 MHz – – – f = 200 MHz

FIGURE 3 – INPUT ADMITTANCE

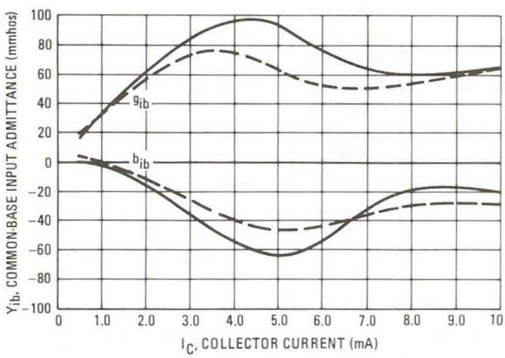


FIGURE 4 – REVERSE TRANSFER ADMITTANCE

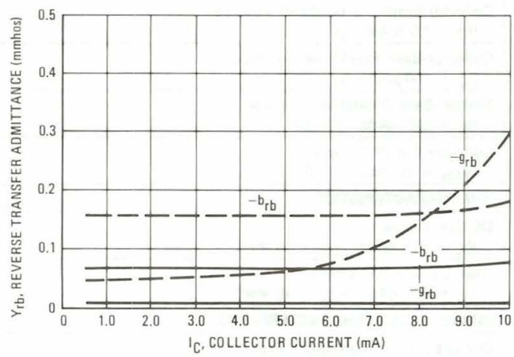


FIGURE 5 – FORWARD TRANSFER ADMITTANCE

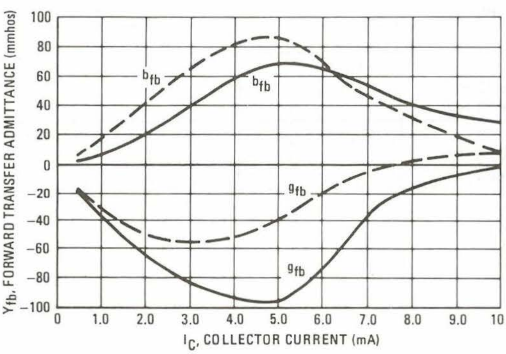


FIGURE 6 – OUTPUT ADMITTANCE

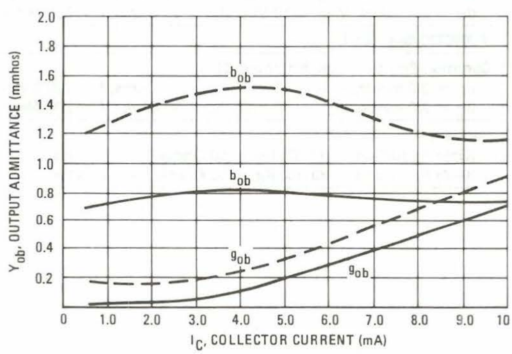


FIGURE 7 — COLLECTOR-BASE TIME CONSTANT

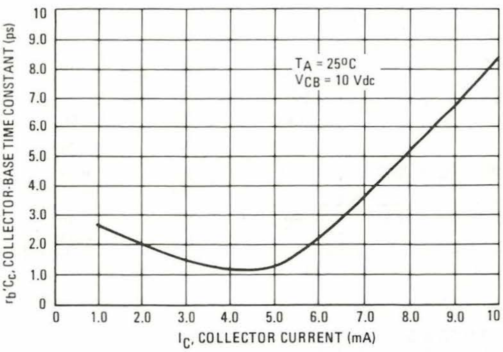


FIGURE 8 — CURRENT-GAIN BANDWIDTH PRODUCT

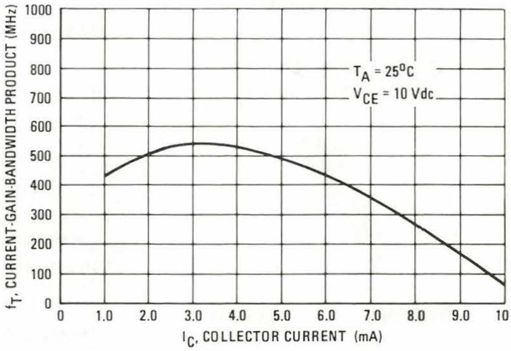
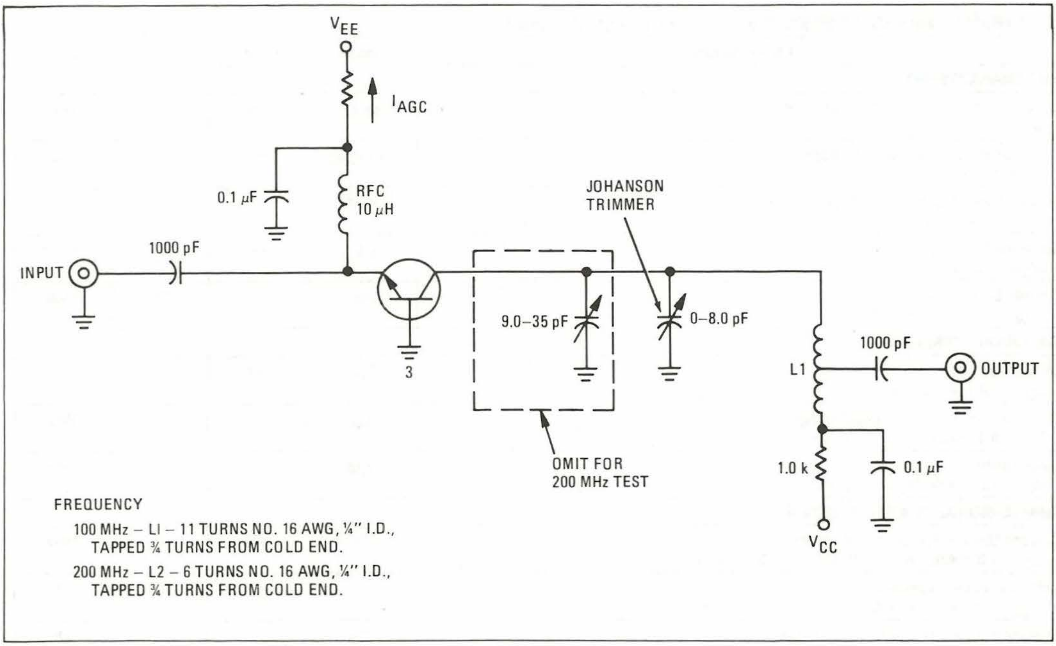


FIGURE 9 — 100-MHz AND 200-MHz COMMON-BASE AMPLIFIER



MPSH10
MPSH11

CASE 29-02, STYLE 2
TO-92 (TO-226AA)

VHF/UHF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	25	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)		$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 25$ Vdc, $I_E = 0$)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{BE} = 2.0$ Vdc, $I_C = 0$)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc)		h_{FE}	60	—	—
Collector-Emitter Saturation Voltage ($I_C = 4.0$ mAdc, $I_B = 0.4$ mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc)		V_{BE}	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)		f_T	650	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{cb}	—	0.7	pF
Common-Base Feedback Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	MPS-H10 MPS-H11	C_{rb}	0.35 0.6	0.65 0.9	pF
Collector Base Time Constant ($I_C = 4.0$ mAdc, $V_{CB} = 10$ Vdc, f = 31.8 MHz)		$r_b'C_c$	—	9.0	ps

2

COMMON-BASE y PARAMETERS versus FREQUENCY
(V_{CB} = 10 Vdc, I_C = 4.0 mAdc, T_A = 25°C)

y_{ib}, INPUT ADMITTANCE

FIGURE 1 – RECTANGULAR FORM

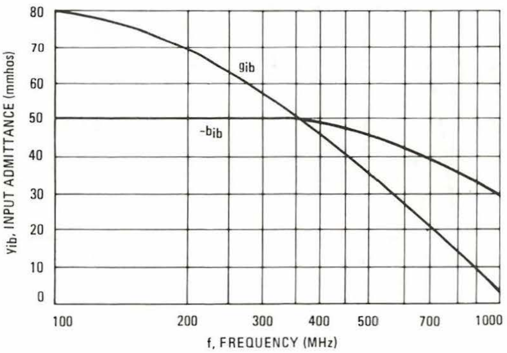
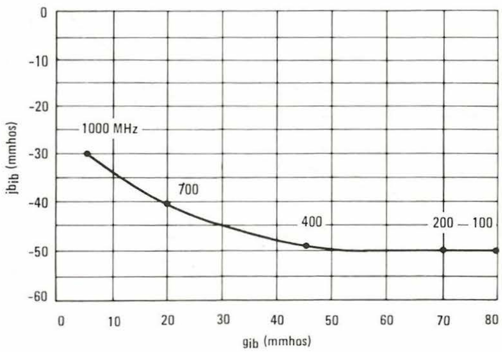


FIGURE 2 – POLAR FORM



COMMON-BASE y PARAMETERS versus FREQUENCY
(V_{CB} = 10 Vdc, I_C = 4.0 mAdc, T_A = 25°C)

y_{fb}, FORWARD TRANSFER ADMITTANCE

FIGURE 3 – RECTANGULAR FORM

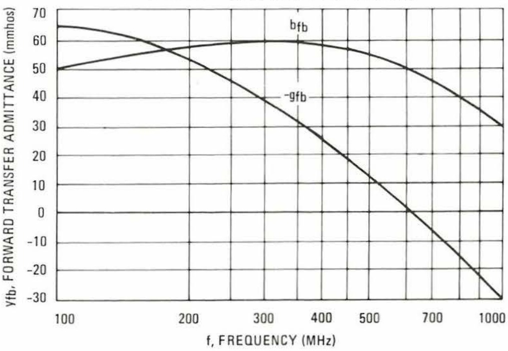
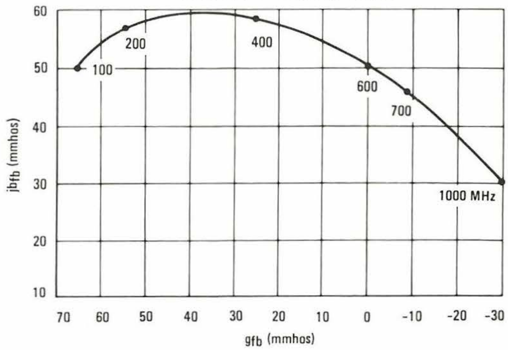


FIGURE 4 – POLAR FORM



y_{rb}, REVERSE TRANSFER ADMITTANCE

FIGURE 5 – RECTANGULAR FORM

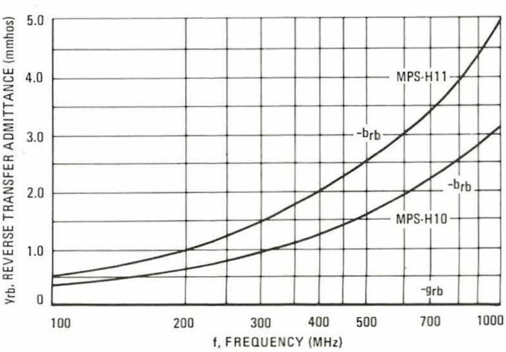
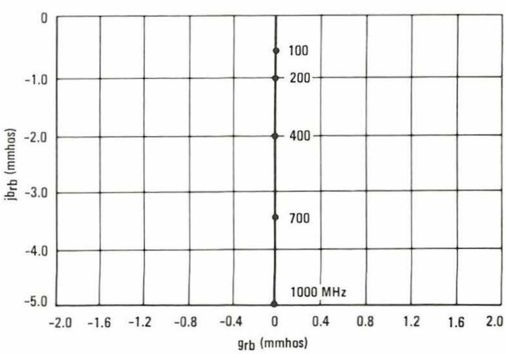


FIGURE 6 – POLAR FORM



y_{ob}, OUTPUT ADMITTANCE

FIGURE 7 – RECTANGULAR FORM

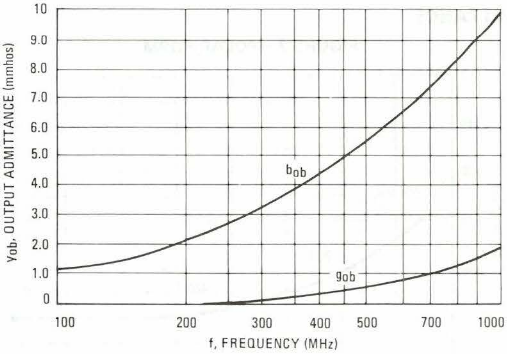
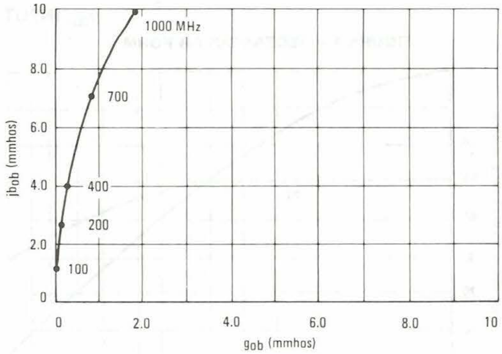


FIGURE 8 – POLAR FORM



MPSH17

CASE 29-02, STYLE 2
TO-92 (TO-226AA)

CATV TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Printed Circuit Board Mounting)	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	25	—	250	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	—	0.5	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	800	—	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, f = 1.0 MHz)	C_{cb}	0.3	—	0.9	pF
Small-Signal Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{fe}	30	—	—	—
Noise Figure ($I_C = 5.0$ mAdc, $V_{CC} = 12$ Vdc, $R_S = 50$ ohms, f = 200 MHz)	NF	—	—	6.0	dB
FUNCTIONAL TEST					
Amplifier Power Gain ($I_C = 5.0$ mAdc, $V_{CC} = 12$ Vdc, $R_S = 50$ ohms, f = 200 MHz)	G_{pe}	—	24	—	dB

2

MPSH20

CASE 29-02, STYLE 2
TO-92 (TO-226AA)

VHF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	350 2.81	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	25	—	—	—
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	400	620	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	—	0.5	0.65	pF
Collector Base Time Constant ($I_E = 4.0$ mAdc, $V_{CB} = 10$ Vdc, f = 31.8 MHz)	$r_{b'}C_c$	—	10	—	ps
Conversion Gain (213 to 45 MHz) ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc, Oscillator Injection = 200 mVdc)	—	18	23	—	dB

CONVERSION GAIN CHARACTERISTICS
(TEST CIRCUIT FIGURE 9)

FIGURE 1 – VARIATION WITH COLLECTOR CURRENT

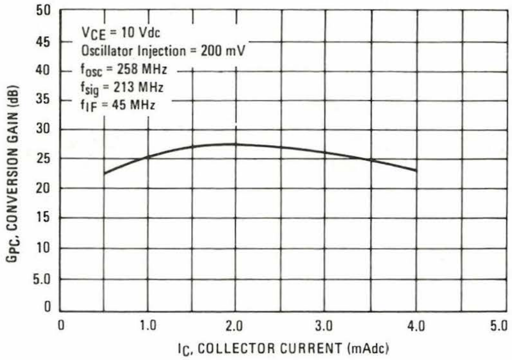
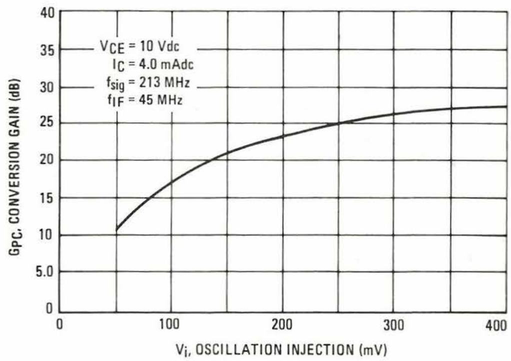


FIGURE 2 – VARIATION WITH INJECTION LEVEL



COMMON-EMITTER y PARAMETERS
(I_C = 4.0 mAdc, V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 3 – INPUT ADMITTANCE

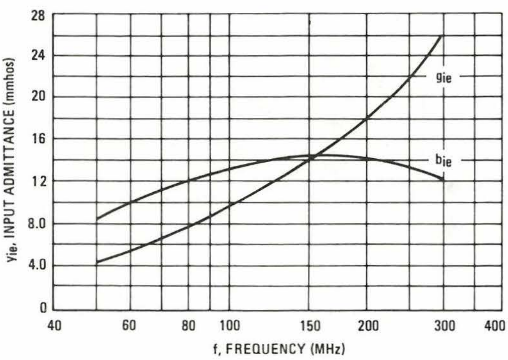
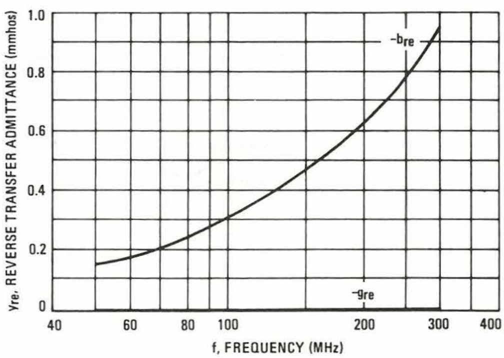


FIGURE 4 – REVERSE TRANSFER ADMITTANCE



COMMON-EMITTER y PARAMETERS
(I_C = 4.0 mAdc, V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 5 – FORWARD TRANSFER ADMITTANCE

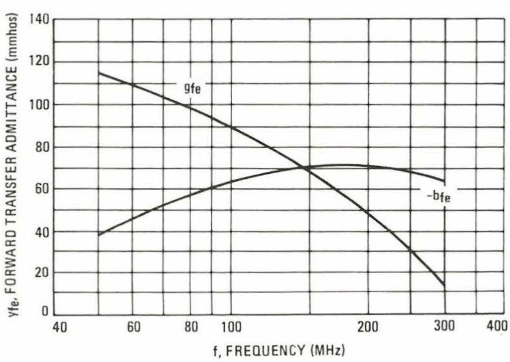
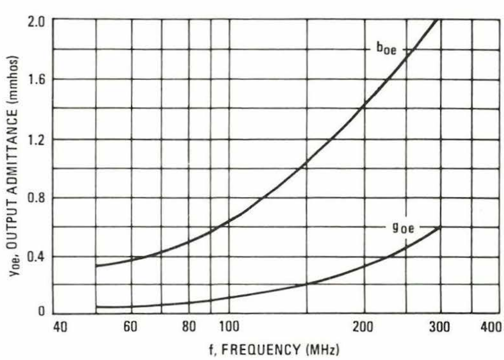


FIGURE 6 – OUTPUT ADMITTANCE



2

FIGURE 7 — CURRENT-GAIN—BANDWIDTH PRODUCT

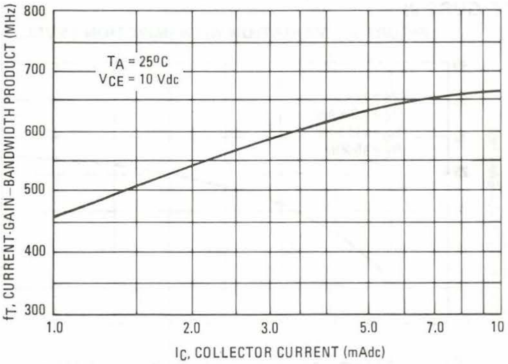


FIGURE 8 — CAPACITANCES

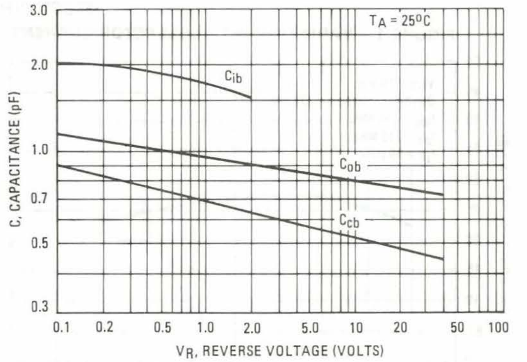
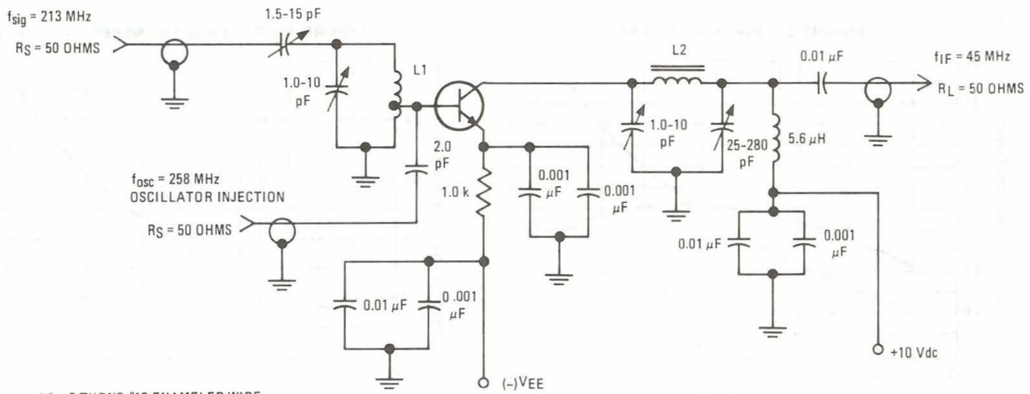


FIGURE 9 — MIXER TEST CIRCUIT



L1 = 3 TURNS #18 ENAMELED WIRE, 1/4" I.D., AIR WOUND, WINDING LENGTH 1/2"; BASE TAPPED 1 TURN FROM GROUND.

L2 = 10 TURNS #26 INSULATED WIRE, WOUND ON 1/4" I.D. COIL FORM, ARNOLD PART NO. A1-10 IRON POWDER CORE.

MPSH24

CASE 29-02, STYLE 2
TO-92 (TO-226AA)

VHF TRANSISTOR

NPN SILICON

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 8.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	30	—	—	—
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 8.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	400	620	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	—	0.25	0.36	pF
Conversion Gain	—				dB
(213 MHz to 45 MHz) ($I_C = 8.0$ mAdc, $V_{CC} = 20$ Vdc, Oscillator Injection = 150 mVrms)		19	24	—	
(60 MHz to 45 MHz) ($I_C = 8.0$ mAdc, $V_{CC} = 20$ Vdc, Oscillator Injection = 150 mVrms)		24	29	—	

2

CONVERSION GAIN CHARACTERISTICS

(TEST CIRCUIT FIGURE 7)

(V_{CC} = 20 Vdc, R_S = R_L = 50 Ohms, f_{if} = 44 MHz, B.W. = 6.0 MHz)

FIGURE 1 – CONVERSION GAIN versus COLLECTOR CURRENT

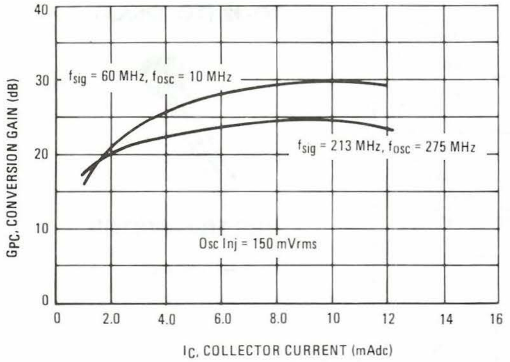
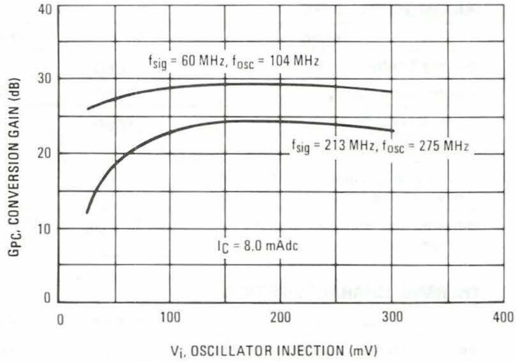


FIGURE 2 – CONVERSION GAIN versus INJECTION LEVEL



COMMON-EMITTER y PARAMETERS

(V_{CE} = 15 Vdc, T_A = 25°C)

FIGURE 3 – INPUT ADMITTANCE

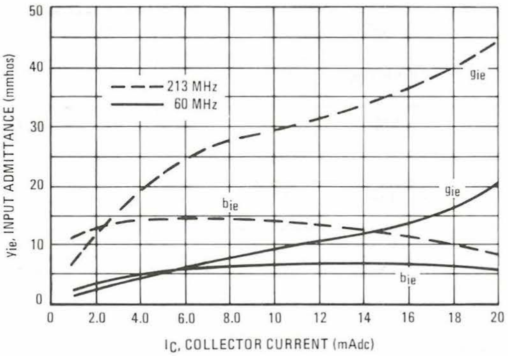


FIGURE 4 – REVERSE TRANSFER ADMITTANCE

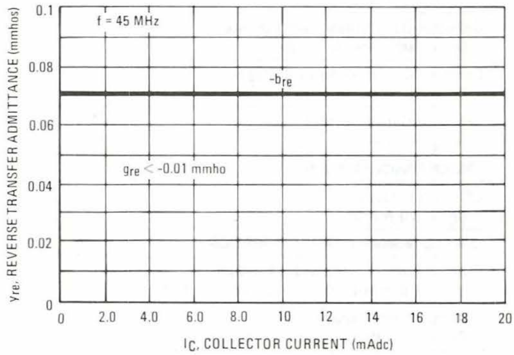


FIGURE 5 – FORWARD TRANSFER ADMITTANCE

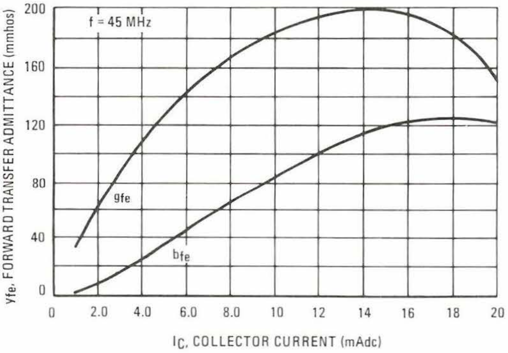


FIGURE 6 – OUTPUT ADMITTANCE

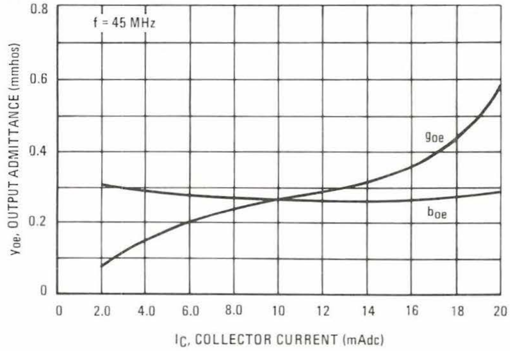
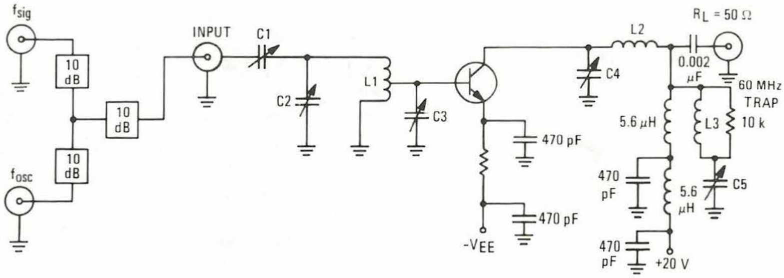


FIGURE 7 — VHF MIXER TEST CIRCUIT
(f_{if} = 44 MHz, B.W. = 6.0 MHz)

f_{sig}	60 MHz	213 MHz
f_{osc}	105 MHz	258 MHz
C1	1.5-20 pF	1.5-20 pF
C2	8.0-60 pF	6.0-12 pF
C3	8.0-60 pF	1.5-20 pF
C4	3.0-35 pF	–
C5	1.5-20 pF	–
L1	5 Turns #26 Air, Tap 1 Turn	3 Turns #16 Air, Tap ½ Turn
L2	10 Turns #26 Air	10 Turns #26 Arnold A1-10 Core
L3	Ohmite Z235	–



2

MPSH30
MPSH31

CASE 29-02, STYLE 2
TO-92 (TO-226AA)

IF AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	20	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	20	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 10$ Vdc, $I_E = 0$)	I_{CBO}	—	50	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 4.0$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	20	200	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 5.0$ mAdc)	$V_{CE(sat)}$	0.1	3.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 5.0$ mAdc)	$V_{BE(sat)}$	—	0.96	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	300	800	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz, emitter guarded)	C_{cb}	—	0.65	pF
Noise Figure ($V_{AGC} = 2.75$ Vdc, $R_S = 50$ ohms, f = 45 MHz)	NF	—	6.0	dB
FUNCTIONAL TESTS				
Power Gain ($V_{AGC} = 2.75$ Vdc, $R_S = 50$ ohms, f = 45 MHz)	G_{pe}	22.5	31	dB
Forward AGC Voltage (Gain Reduction = 30 dB, $R_S = 50$ ohms, f = 45 MHz) MPS-H30 MPS-H31	V_{AGC}	4.4 5.2	5.4 6.2	Vdc

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

MPSH32

CASE 29-02, STYLE 2
TO-92 (TO-226AA)

VHF TRANSISTOR

NPN SILICON

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 10$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 4.0$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	27	35	200	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 5.0$ mAdc)	$V_{CE(sat)}$	—	1.5	3.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 5.0$ mAdc)	$V_{BE(sat)}$	—	0.9	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	300	440	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz) (Emitter Guarded)	C_{cb}	—	0.2	0.22	pF
Noise Figure ($I_E \approx 4.0$ mAdc, $V_{CE} \approx 9.3$ Vdc, $V_{AGC} = 2.75$ Vdc, $R_S = 50$ Ohms, f = 45 MHz)	NF	—	3.3	—	dB
FUNCTIONAL TEST					
Amplifier Power Gain ($I_E \approx 4.0$ mAdc, $V_{CE} \approx 9.3$ Vdc, $V_{AGC} = 2.75$ Vdc, $R_S = 50$ Ohms, f = 45 MHz)	G_{pe}	22.5	25	—	dB
Forward AGC Voltage (Gain Reduction = 30 dB, $R_S = 50$ Ohms, f = 45 MHz)	V_{AGC}	—	5.5	—	Vdc
SUMMARY-COMMON EMITTER PARAMETERS ($V_{CE} = 10$ Vdc, $I_C = 4.0$ mAdc, f = 45 MHz)					
Input Conductance	g_{ie}	—	6.0	—	mmhos
Input Capacitance	C_{ieo}	—	33	—	pF
Forward Transfer Admittance Magnitude	$\|y_{fe}\|$	—	110	—	mmhos
Forward Transfer Admittance Phase Angle	$\angle y_{fe}$	—	−22	—	Degrees
Feedback Capacitance	C_{re}	—	0.2	—	pF
Output Conductance	g_{oe}	—	20	—	μmhos
Output Capaticance	C_{oe}	—	1.4	—	pF
Maximum Unilateralized Power Gain $G_{um} = \frac{\|y_{fe}\|^2}{4\ g_{ie}\ g_{oe}}$	G_{um}	—	44	—	dB

2

AGC CHARACTERISTICS
V_{CC} = 12 Vdc, R_S = 50 Ohms, f = 45 MHz, See Figure 10

FIGURE 1 – POWER GAIN

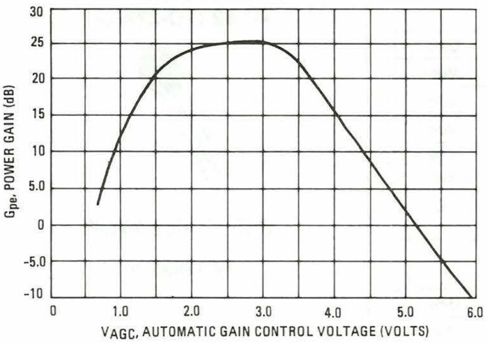
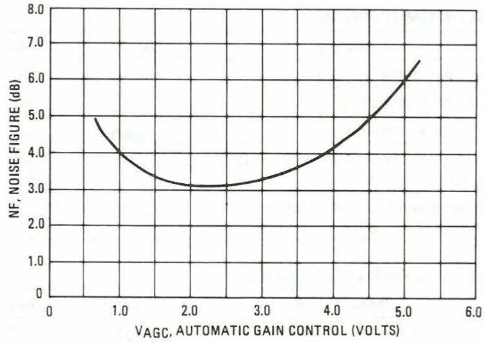


FIGURE 2 – NOISE FIGURE



COMMON-EMITTER y PARAMETERS
V_{CE} = 10 Vdc, f = 45 MHz, T_A = 25°C

FIGURE 3 – INPUT ADMITTANCE

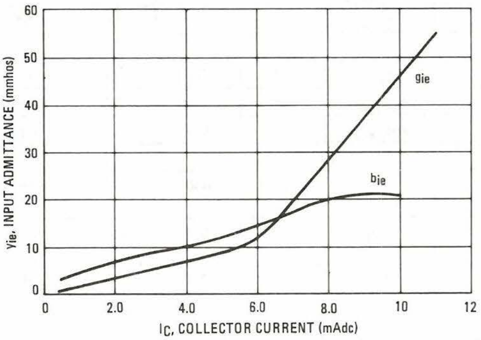


FIGURE 4 – REVERSE TRANSFER ADMITTANCE

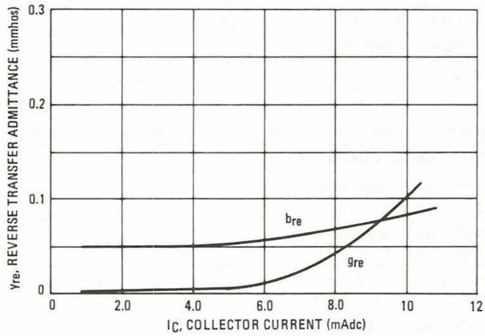


FIGURE 5 – FORWARD TRANSFER ADMITTANCE

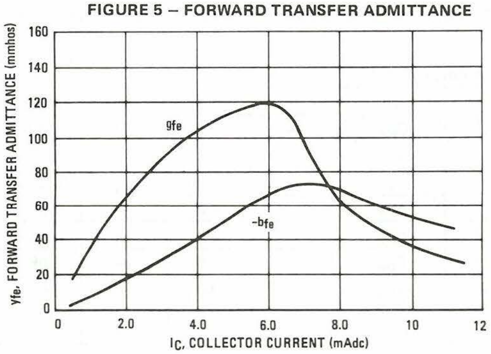


FIGURE 6 – OUTPUT ADMITTANCE

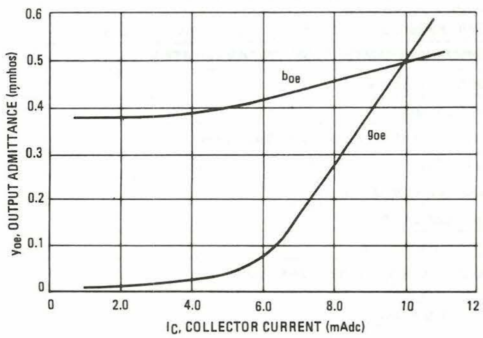


FIGURE 7 — DC CURRENT GAIN

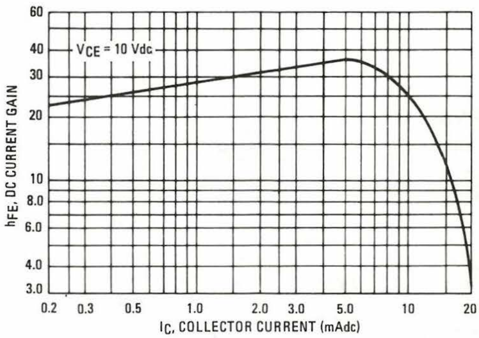


FIGURE 8 — COLLECTOR-BASE CAPACITANCE

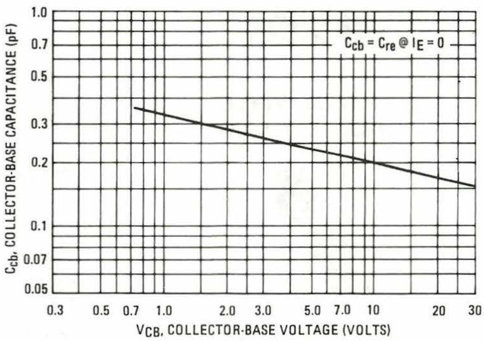


FIGURE 9 — CURRENT-GAIN—BANDWIDTH PRODUCT

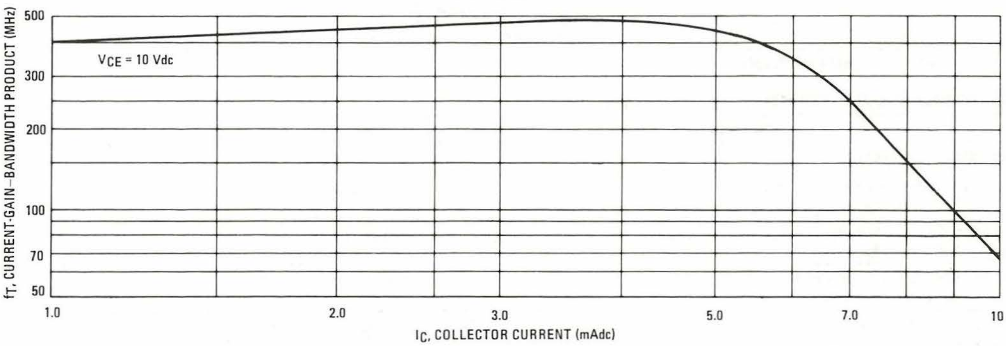
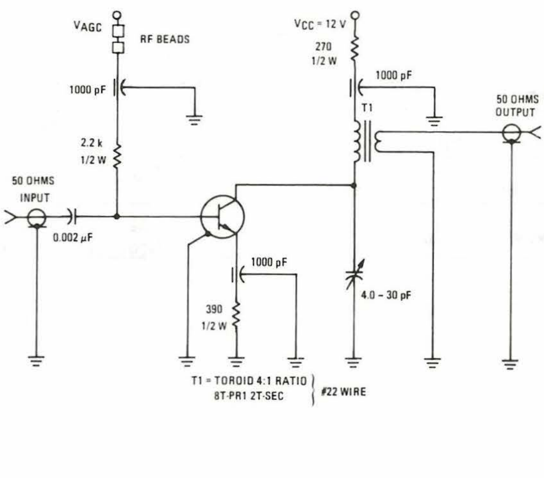


FIGURE 10 — 45 MHz FUNCTIONAL TEST CIRCUIT
(UNNEUTRALIZED)



MPSH34

CASE 29-02, STYLE 2
TO-92 (TO-226AA)

IF TRANSISTOR

NPN SILICON

Refer to MPSH24 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CBO}	45	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	45	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	45	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 7.0 mAdc, V_{CE} = 15 Vdc) (I_C = 20 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	 40 15	 — —	 — —	—
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	$V_{CE(sat)}$	—	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 7.0 mAdc, V_{CE} = 15 Vdc)	$V_{BE(on)}$	—	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 15 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	f_T	500	720	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	0.25	0.32	pF
Current-Gain — Bandwidth Ratio (I_C = 15 mAdc to I_C = 20 mAdc, V_{CE} = 15 Vdc)	$\frac{f_{T15}}{f_{T20}}$	—	—	1.6	—

MPSH54
MPSH55

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	80	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	80	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.5$ mAdc, $V_{CE} = 10$ Vdc) MPSH54 MPSH55	h_{FE}	30 30	— —	120 150	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	—	0.25	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 1.5$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	80	—	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, f = 1.0 MHz)	C_{cb}	—	—	1.6	pF
Output Admittance ($I_C = 1.5$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{oe}	—	—	15	μmhos
Noise Figure ($I_C = 1.5$ mAdc, $V_{CE} = 10$ Vdc, $R_S = 50$ ohms, f = 1.0 MHz) MPSH54	NF	—	—	2.0	dB

2

MPSH81

CASE 29-02, STYLE 2
TO-92 (TO-226AA)

RF AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	350 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 10$ Vdc, $I_E = 0$)	I_{CBO}	—	—	100	nAdc
Emitter Cutoff Current ($V_{BE} = 2.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	60	—	—	—
Collector-Emitter Saturation Voltage ($I_C = 5.0$ mAdc, $I_B = 0.5$ mAdc)	$V_{CE(sat)}$	—	—	0.5	Vdc
Base-Emitter On Voltage ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc)	$V_{BE(on)}$	—	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	600	—	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	—	—	0.85	pF
Collector-Emitter Capacitance ($I_B = 0$, $V_{CB} = 10$ Vdc, f = 1.0 MHz)	C_{ce}	—	—	0.65	pF

TYPICAL COMMON-BASE y-PARAMETERS
(V_{CB} = 10 Vdc, T_A = 25°C, Frequency Points in MHz)

FIGURE 1 — INPUT ADMITTANCE

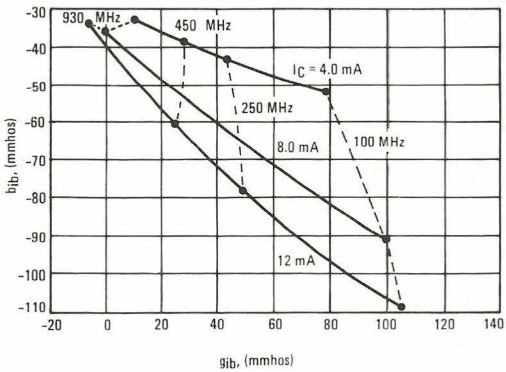


FIGURE 2 — REVERSE TRANSFER ADMITTANCE

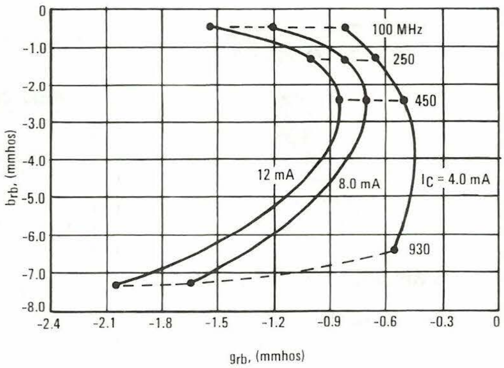


FIGURE 3 — FORWARD TRANSFER ADMITTANCE

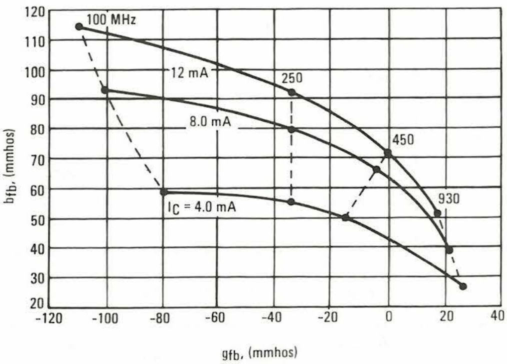


FIGURE 4 — OUTPUT ADMITTANCE

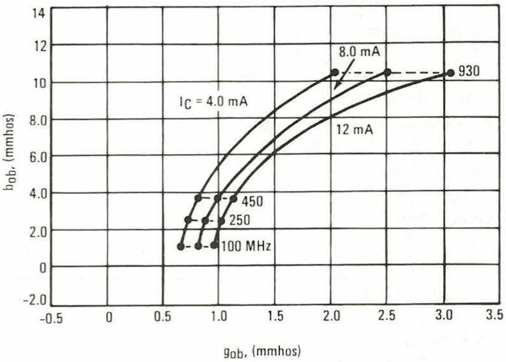
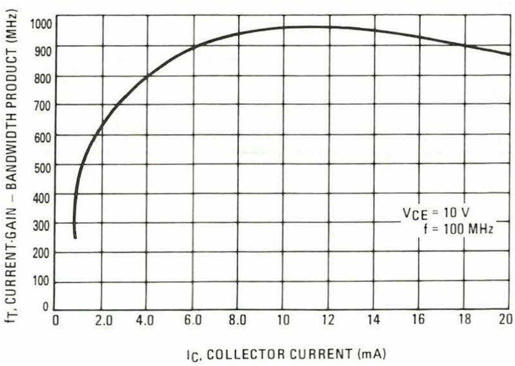


FIGURE 5 — CURRENT-GAIN — BANDWIDTH PRODUCT



MPSL01

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N5550 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	120	Vdc
Collector-Base Voltage	V_{CBO}	140	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	150	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	120	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	140	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 75 Vdc, I_E = 0)	I_{CBO}	—	1.0	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	50	300	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	 — —	 0.20 0.30	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)(1)	$V_{BE(sat)}$	 — —	 1.2 1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(1) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	60	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	8.0	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	30	—	—

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

MPSL51

CASE 29-02, STYLE 1
TO-92 (TO-226AA)

AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N5400 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	100	Vdc
Collector-Base Voltage	V_{CBO}	100	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	600	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 12.0	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	100	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	100	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$)	I_{CBO}	—	1.0	μAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain(1) ($I_C = 50$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	40	250	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{CE(sat)}$	 — —	 0.25 0.30	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{BE(sat)}$	 — —	 1.2 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	60	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	8.0	pF
Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{fe}	20	—	—

(1) Pulse Test: Pulse Test = 300 μs, Duty Cycle = 2.0%.

2

MPSW01
MPSW01A

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

HIGH CURRENT TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage MPSW01 / MPSW01A	V_{CEO}	30 / 40	Vdc
Collector-Base Voltage MPSW01 / MPSW01A	V_{CBO}	40 / 50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	1000	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 / 8.0	Watt / mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.5 / 20	Watts / mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	MPSW01 / MPSW01A	$V_{(BR)CEO}$	30 / 40	— / —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	MPSW01 / MPSW01A	$V_{(BR)CBO}$	40 / 50	— / —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$) ($V_{CB} = 40$ Vdc, $I_E = 0$)	MPSW01 / MPSW01A	I_{CBO}	— / —	0.1 / 0.1	μAdc
Emitter Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 1000$ mAdc, $V_{CE} = 1.0$ Vdc)		h_{FE}	55 / 60 / 50	— / — / —	—
Collector-Emitter Saturation Voltage ($I_C = 1000$ mAdc, $I_B = 100$ mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage ($I_C = 1000$ mAdc, $V_{CE} = 1.0$ Vdc)		$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)		f_T	50	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	20	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — DC CURRENT GAIN

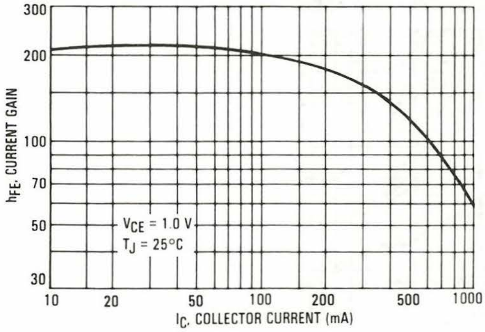


FIGURE 2 — COLLECTOR SATURATION REGION

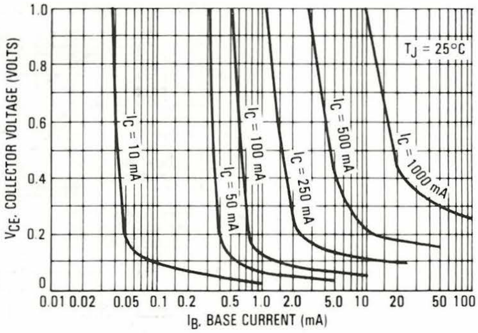


FIGURE 3 — ON VOLTAGES

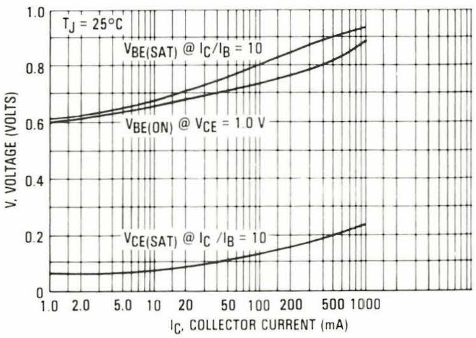


FIGURE 4 — TEMPERATURE COEFFICIENT

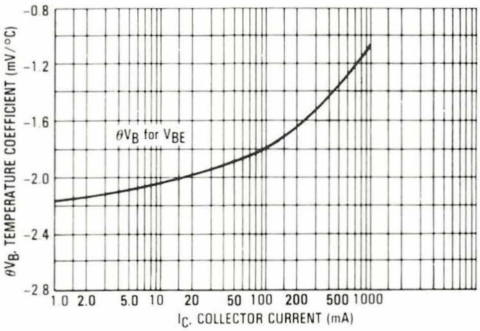


FIGURE 5 — CURRENT GAIN-BANDWIDTH PRODUCT

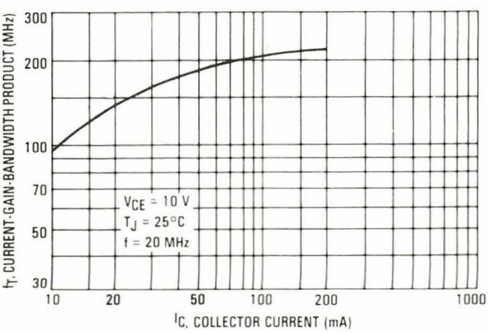


FIGURE 6 — CAPACITANCE

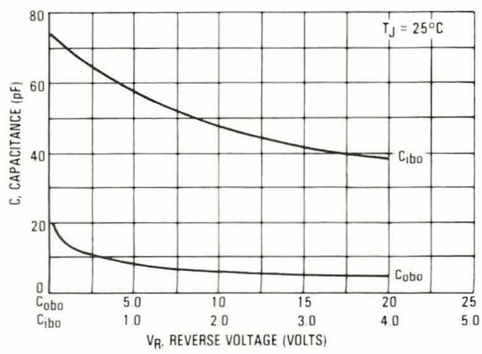
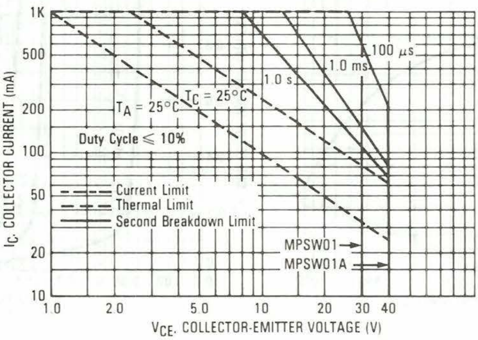


FIGURE 7 — ACTIVE REGION-SAFE OPERATING AREA



MPSW05
MPSW06

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MPSW05	MPSW06	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.5 20		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	 MPSW05 MPSW06	$V_{(BR)CEO}$	 60 80	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 40$ Vdc, $I_B = 0$) ($V_{CE} = 60$ Vdc, $I_B = 0$)	 MPSW05 MPSW06	I_{CEO}	 — —	 0.5 0.5	μAdc
Collector Cutoff Current ($V_{CB} = 40$ Vdc, $I_E = 0$) ($V_{CB} = 60$ Vdc, $I_E = 0$)	 MPSW05 MPSW06	I_{CBO}	 — —	 0.1 0.1	μAdc
Emitter Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 250$ mAdc, $V_{CE} = 1.0$ Vdc)		h_{FE}	 80 60	 — —	—
Collector-Emitter Saturation Voltage ($I_C = 250$ mAdc, $I_B = 10$ mAdc)		$V_{CE(sat)}$	—	0.40	Vdc
Base-Emitter Saturation Voltage ($I_C = 250$ mAdc, $V_{CE} = 5.0$ Vdc)		$V_{BE(sat)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 200$ mAdc, $V_{CE} = 5.0$ Vdc, f = 20 MHz)		f_T	50	—	MHz
Output Capacitance ($V_{CB} = 10$ V, f = 1.0 MHz)		C_{obo}	—	12	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPSW10

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

HIGH VOLTAGE TRANSISTOR

Refer to MPSW42 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CBO}	300	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	300	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	300	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 200$ Vdc, $I_E = 0$)	I_{CBO}	—	0.2	μAdc
Emitter Cutoff Current ($V_{EB} = 6.0$ Vdc, $I_C = 0$)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	 25 40 40	 — — —	—
Collector-Emitter Saturation Voltage ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc)	$V_{CE(sat)}$	—	0.75	Vdc
Base-Emitter On Voltage ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)	$V_{BE(on)}$	—	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 20 MHz)	f_T	45	—	MHz
Collector-Base Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	—	3.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPSW13
MPSW14

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

DARLINGTON TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	10	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu Adc$, $V_{BE} = 0$)		$V_{(BR)CES}$	30	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{EB} = 10$ Vdc, $I_C = 0$)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)	 MPSW13 MPSW14 MPSW13 MPSW14	h_{FE}	 5000 10,000 10,000 20,000	 — — — —	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 0.1$ mAdc)		$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)		$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)		f_T	125	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$.

2

FIGURE 1 — ACTIVE REGION SAFE OPERATING AREA

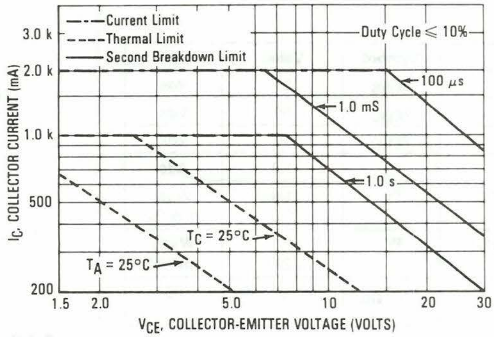


FIGURE 2 — DC CURRENT GAIN

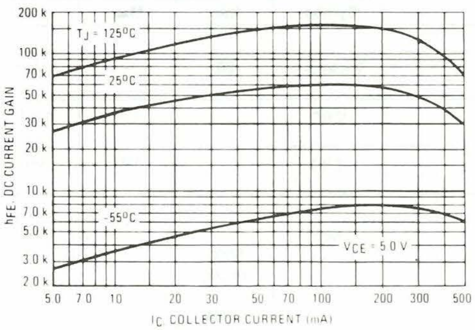


FIGURE 3 — COLLECTOR-SATURATION REGION

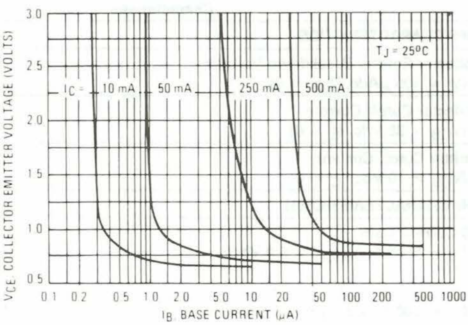


FIGURE 4 — ON VOLTAGES

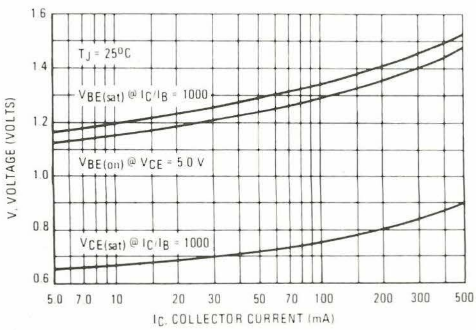


FIGURE 5 — TEMPERATURE COEFFICIENTS

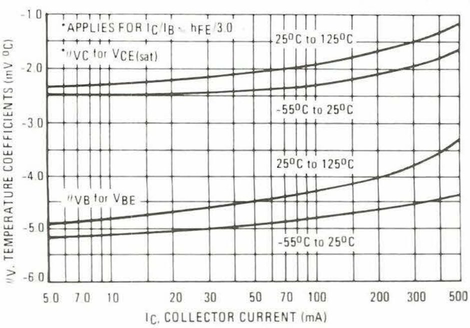


FIGURE 6 — HIGH FREQUENCY CURRENT GAIN

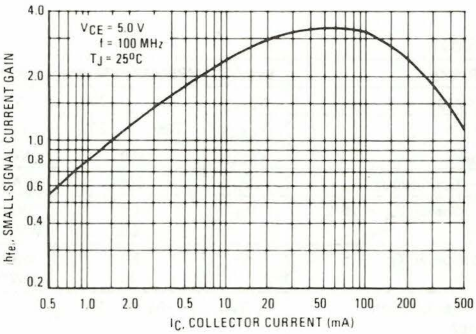
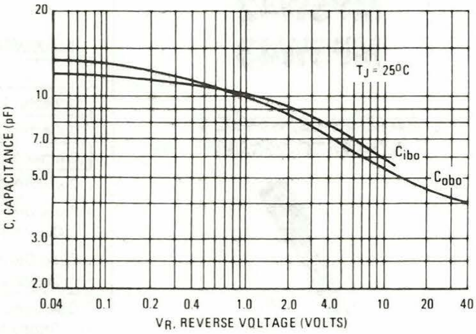


FIGURE 7 — CAPACITANCE



2

MPSW42
MPSW43

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

HIGH VOLTAGE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MPSW42	MPSW43	Unit
Collector-Emitter Voltage	V_{CEO}	300	200	Vdc
Collector-Base Voltage	V_{CBO}	300	200	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.5 20		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	 MPSW42 MPSW43	$V_{(BR)CEO}$	 300 200	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 MPSW42 MPSW43	$V_{(BR)CBO}$	 300 200	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0) (V_{CB} = 160 Vdc, I_E = 0)	 MPSW42 MPSW43	I_{CBO}	 — —	 0.1 0.1	μAdc
Emitter Cutoff Current (V_{EB} = 6.0 Vdc, I_C = 0) (V_{EB} = 4.0 Vdc, I_C = 0)	 MPSW42 MPSW43	I_{EBO}	 — —	 0.1 0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	 Both Types Both Types MPSW42 MPSW43	h_{FE}	 25 40 40 40	 — — — —	—
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	 MPSW42 MPSW43	$V_{CE(sat)}$	 — —	 0.5 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)		f_T	50	—	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	 MPSW42 MPSW43	C_{cb}	 — —	 3.0 4.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — D.C. CURRENT GAIN

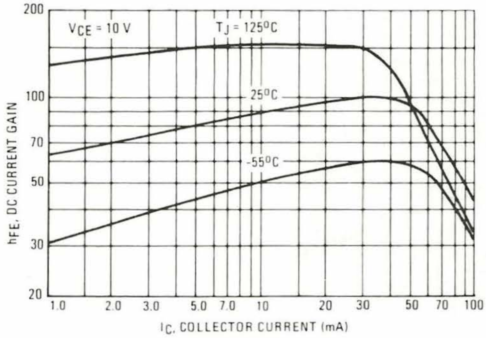


FIGURE 2 — COLLECTOR SATURATION REGION

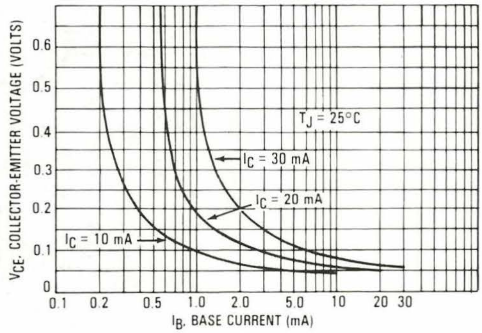


FIGURE 3 — ON VOLTAGES

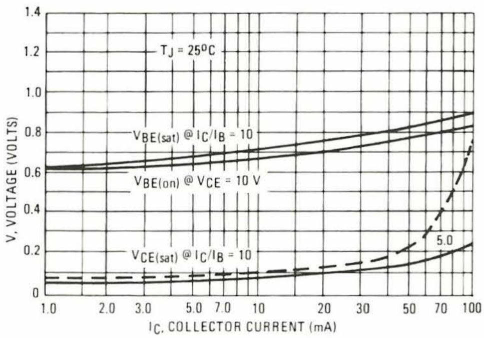


FIGURE 4 — TEMPERATURE COEFFICIENTS

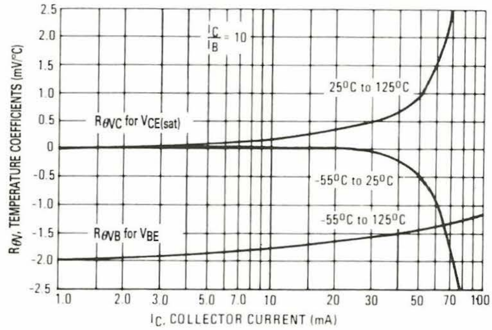


FIGURE 5 — CAPACITANCE

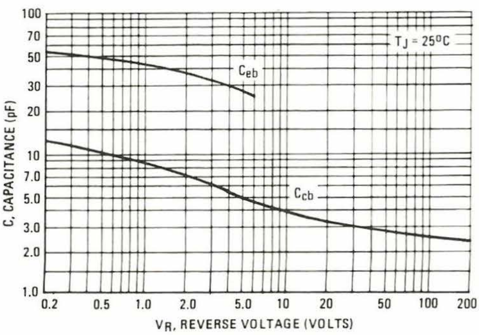


FIGURE 6 — CURRENT GAIN - BANDWIDTH PRODUCT

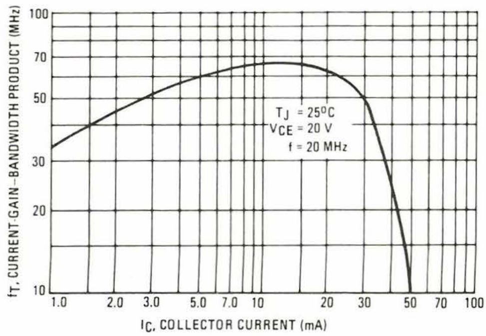
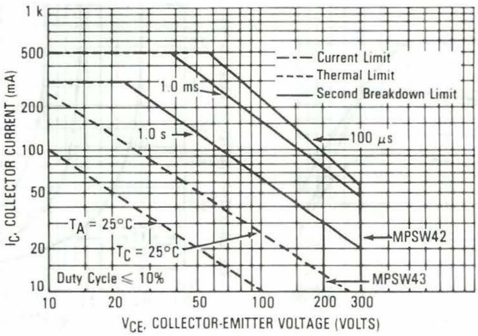


FIGURE 7 — ACTIVE REGION SAFE OPERATING AREA



MPSW45

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

DARLINGTON TRANSISTOR

NPN SILICON

Refer to 2N6426 for graphs.

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CBO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	12	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu Adc$, $V_{BE} = 0$)	$V_{(BR)CES}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu Adc$, $I_E = 0$)	$V_{(BR)CBO}$	50	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu Adc$, $I_C = 0$)	$V_{(BR)EBO}$	12	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{EB} = 10$ Vdc, $I_C = 0$)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain ($I_C = 200$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 500$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 1.0$ Adc, $V_{CE} = 5.0$ Vdc)	h_{FE}	 25,000 15,000 4,000	 150,000 — —	—
Collector-Emitter Saturation Voltage ($I_C = 1.0$ Adc, $I_B = 2.0$ mAdc)	$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 1.0$ Adc, $I_B = 2.0$ mAdc)	$V_{BE(sat)}$	—	2.0	Vdc
Base-Emitter On Voltage ($I_C = 1.0$ Adc, $V_{CE} = 5.0$ Vdc)	$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 200$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)	f_T	100	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	—	6.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

MPSW51
MPSW51A

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

HIGH CURRENT TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage MPSW51 / MPSW51A	V_{CEO}	30 / 40	Vdc
Collector-Base Voltage MPSW51 / MPSW51A	V_{CBO}	40 / 50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	1000	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 / 8.0	Watt / mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.5 / 20	Watts / mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	MPSW51	$V_{(BR)CEO}$	30	—	Vdc
	MPSW51A		40	—	
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	MPSW51	$V_{(BR)CBO}$	40	—	Vdc
	MPSW51A		50	—	
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	MPSW51	I_{CBO}	—	0.1	μAdc
($V_{CB} = 40$ Vdc, $I_E = 0$)	MPSW51A		—	0.1	
Emitter Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)		h_{FE}	55	—	—
($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)			60	—	
($I_C = 1000$ mAdc, $V_{CE} = 1.0$ Vdc)			50	—	
Collector-Emitter Saturation Voltage ($I_C = 1000$ mAdc, $I_B = 100$ mAdc)		$V_{CE(sat)}$	—	0.7	Vdc
Base-Emitter On Voltage ($I_C = 1000$ mAdc, $V_{CE} = 1.0$ Vdc)		$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)		f_T	50	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	30	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — DC CURRENT GAIN

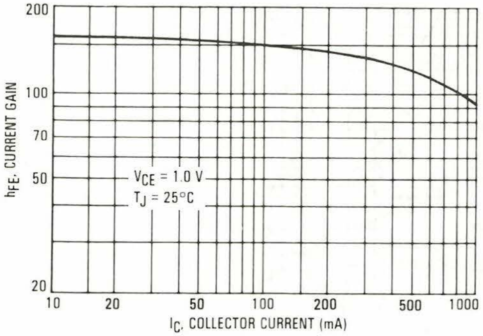


FIGURE 2 — COLLECTOR SATURATION REGION

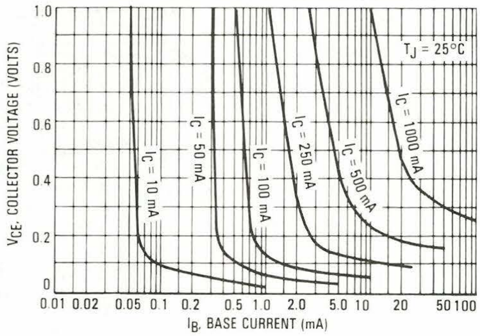


FIGURE 3 — ON VOLTAGES

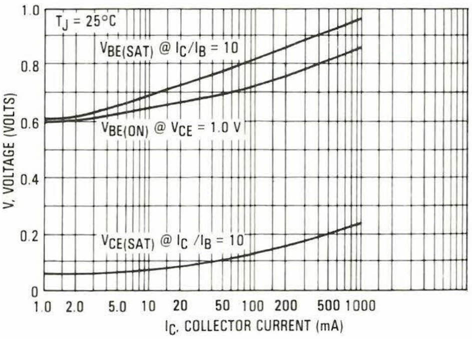


FIGURE 4 — TEMPERATURE COEFFICIENT

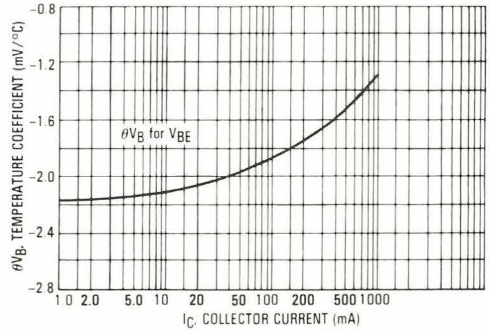


FIGURE 5 — CURRENT GAIN-BANDWIDTH PRODUCT

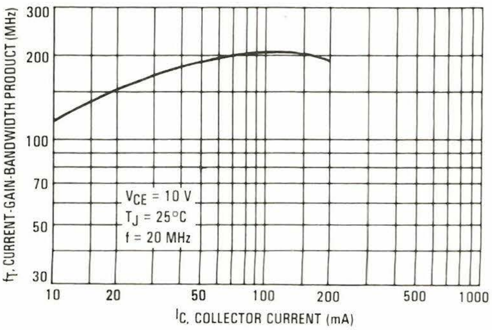
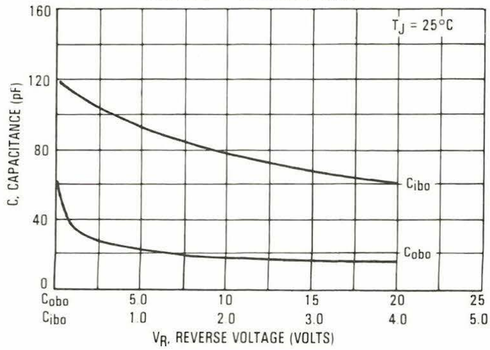
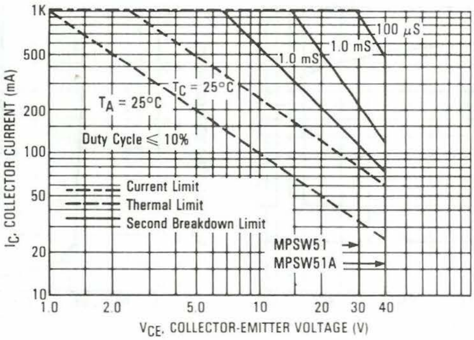


FIGURE 6 — CAPACITANCE



2

FIGURE 7 — ACTIVE REGION-SAFE OPERATING AREA



MPSW55
MPSW56

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

AMPLIFIER TRANSISTOR

PNP SILICON

2

MAXIMUM RATINGS

Rating	Symbol	MPSW55	MPSW56	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	 MPSW55 MPSW56	$V_{(BR)CEO}$	 60 80	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CE} = 40 Vdc, I_B = 0) (V_{CE} = 60 Vdc, I_B = 0)	 MPSW55 MPSW56	I_{CEO}	 — —	 0.5 0.5	μAdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0)	 MPSW55 MPSW56	I_{CBO}	 — —	 0.1 0.1	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 1.0 Vdc) (I_C = 250 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	 80 50	 — —	—
Collector-Emitter Saturation Voltage (I_C = 250 mAdc, I_B = 10 mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 250 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	50	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, f = 1.0 MHz)		C_{obo}	—	15	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2

FIGURE 1 — D.C. CURRENT GAIN

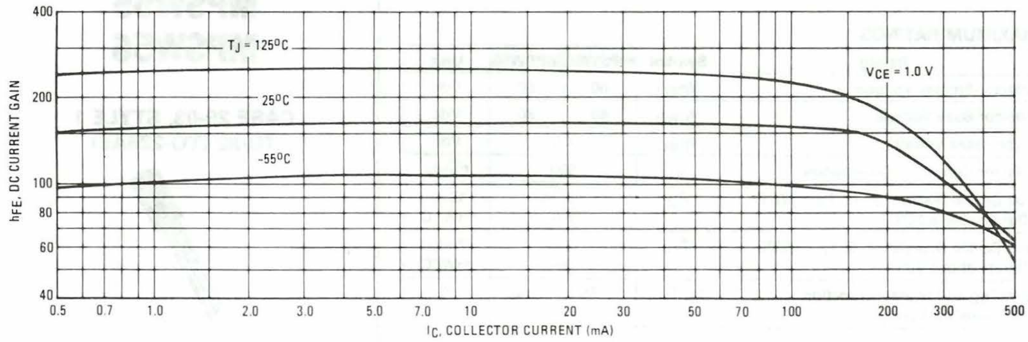


FIGURE 2 — COLLECTOR SATURATION REGION

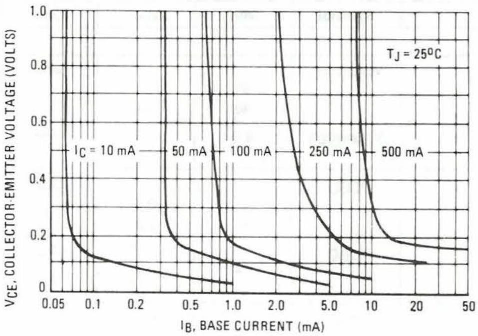


FIGURE 3 — ON VOLTAGES

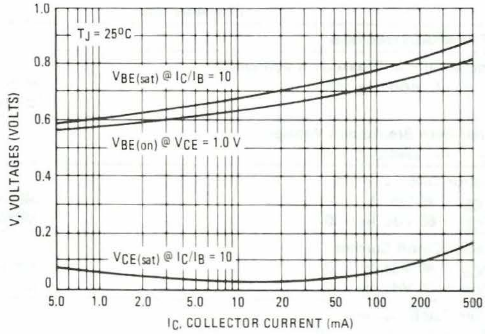


FIGURE 4 — BASE-EMITTER TEMPERATURE COEFFICIENT

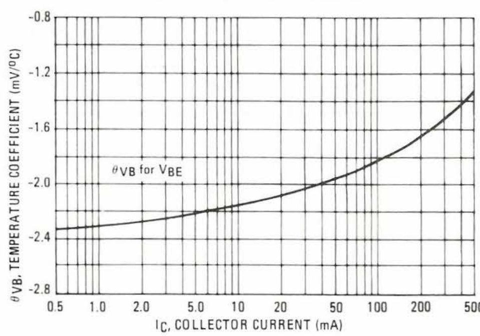


FIGURE 5 — CAPACITANCE

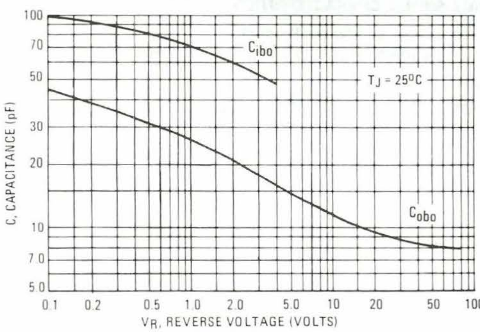


FIGURE 6 — CURRENT GAIN - BANDWIDTH PRODUCT

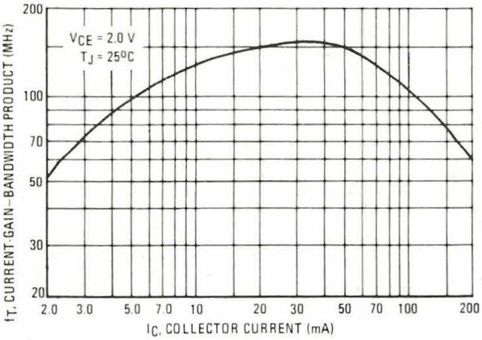
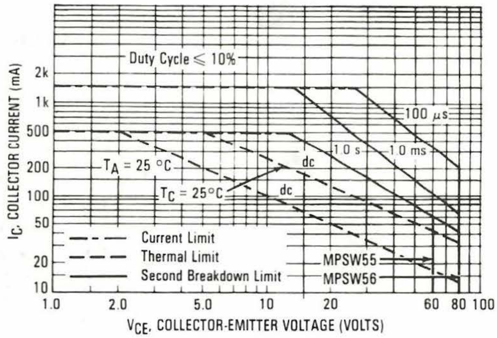


FIGURE 7 — ACTIVE REGION - SAFE OPERATING AREA



2

MPSW60

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

HIGH VOLTAGE TRANSISTOR

PNP SILICON

Refer to MPSW92 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CBO}	300	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	300	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	300	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10.0 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0)	I_{CBO}	—	0.2	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 25 30 25	 — — —	—
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	$V_{CE(sat)}$	—	0.75	Vdc
Base-Emitter On Voltage (I_C = 20 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	f_T	60	—	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 10 MHz)	C_{cb}	—	8.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPSW63
MPSW64

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

DARLINGTON TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MPSW63 MPSW64	Unit
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	10	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu Adc$, $V_{BE} = 0$)		$V_{(BR)CES}$	30	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{EB} = 10$ Vdc, $I_C = 0$)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain		h_{FE}			—
($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	MPSW63		5,000	—	
	MPSW64		10,000	—	
($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)	MPSW63		10,000	—	
	MPSW64		20,000	—	
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 0.1$ mAdc)		$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)		$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)		f_T	125	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$.

2

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 – DC CURRENT GAIN

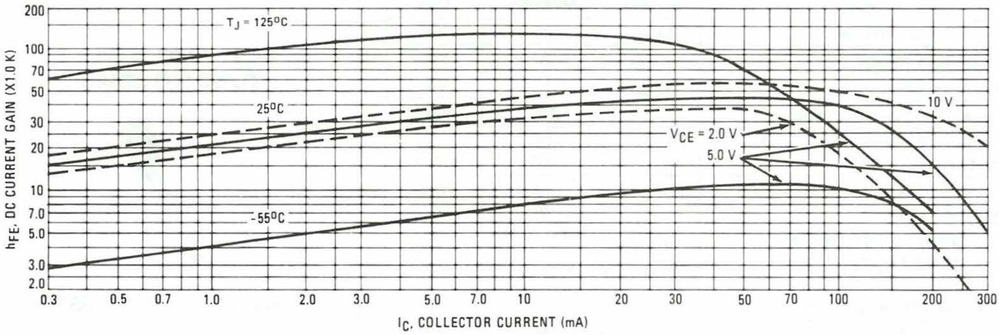


FIGURE 2 – "ON" VOLTAGE

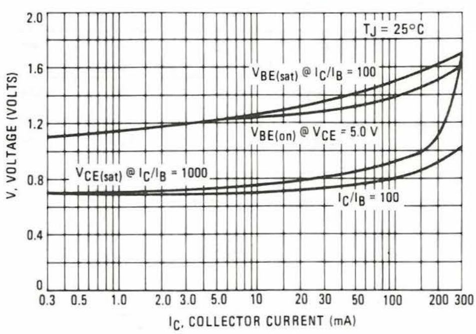


FIGURE 3 – COLLECTOR SATURATION REGION

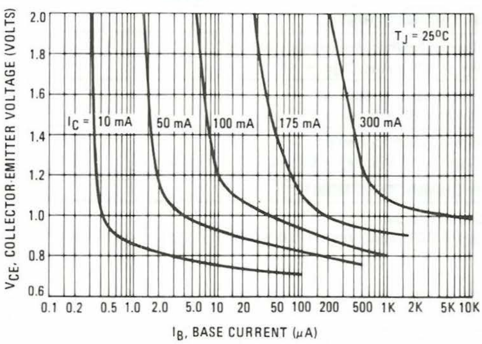


FIGURE 4 – TEMPERATURE COEFFICIENTS

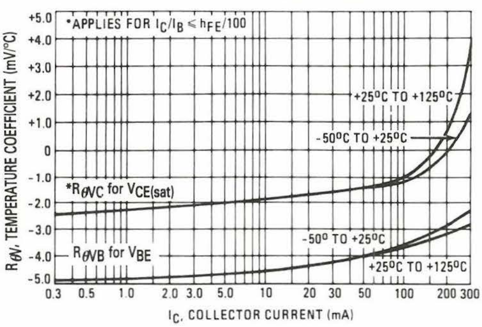


FIGURE 5 – CURRENT-GAIN–BANDWIDTH PRODUCT

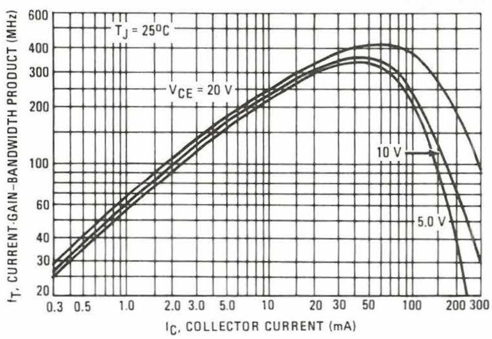


FIGURE 6 — CAPACITANCE

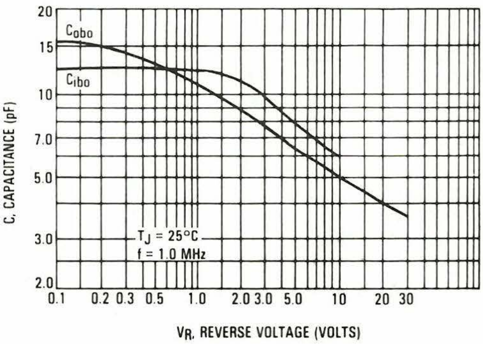
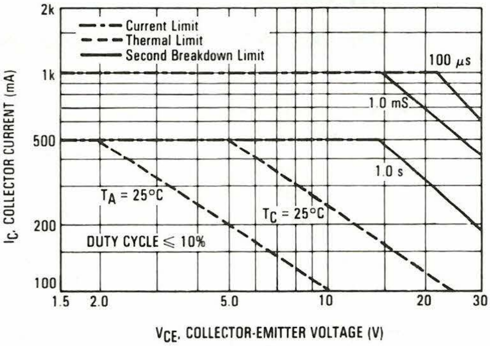


FIGURE 7 — ACTIVE REGION, SAFE OPERATING AREA



2

MPSW92
MPSW93

CASE 29-03, STYLE 1
TO-92 (TO-226AE)

HIGH VOLTAGE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MPSW92	MPSW93	Unit
Collector-Emitter Voltage	V_{CEO}	300	200	Vdc
Collector-Base Voltage	V_{CBO}	300	200	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 20		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	MPSW92 MPSW93	$V_{(BR)CEO}$	300 200	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MPSW92 MPSW93	$V_{(BR)CBO}$	300 200	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0) (V_{CB} = 160 Vdc, I_E = 0)	 MPSW92 MPSW93	I_{CBO}	 — —	 0.25 0.25	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	 Both Types Both Types MPSW92 MPSW93	h_{FE}	 25 40 25 25	 — — — —	—
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	MPSW92 MPSW93	$V_{CE(sat)}$	— —	0.5 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)		f_T	50	—	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	MPSW92 MPSW93	C_{cb}	— —	6.0 8.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — D.C. CURRENT GAIN

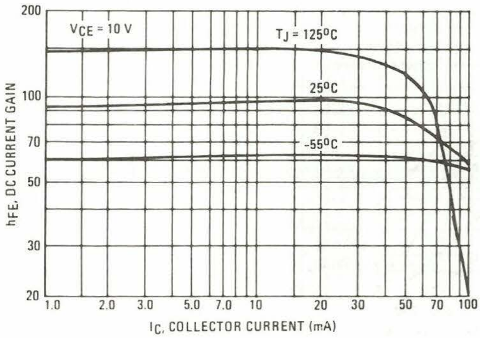


FIGURE 2 — COLLECTOR SATURATION REGION

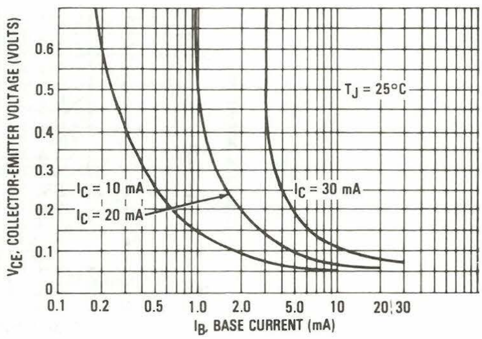


FIGURE 3 — ON VOLTAGES

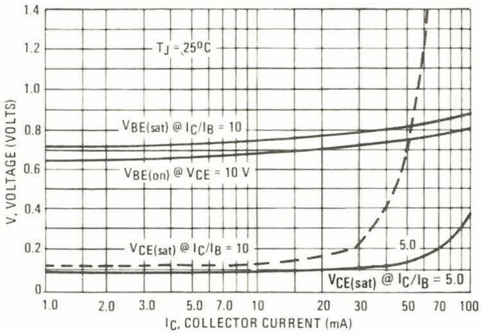


FIGURE 4 — TEMPERATURE COEFFICIENTS

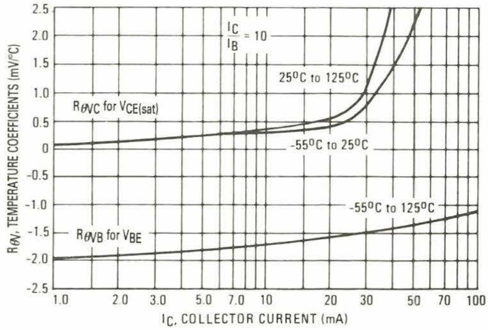


FIGURE 5 — CAPACITANCE

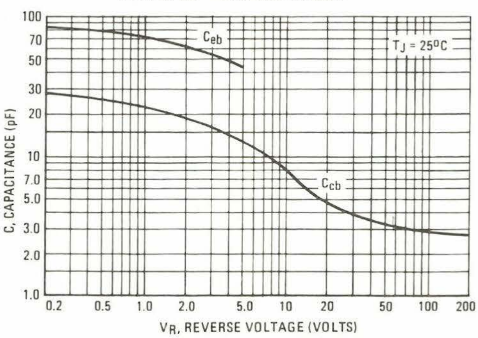
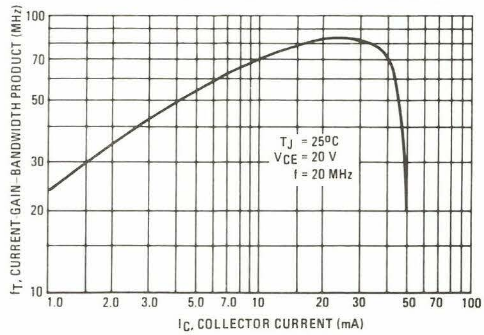
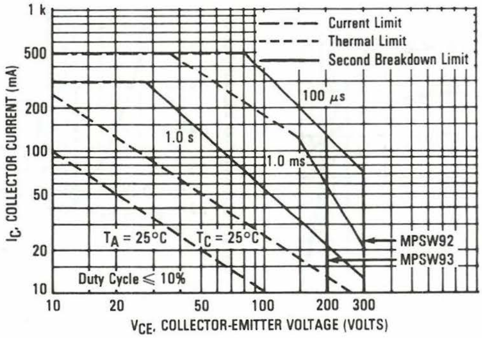


FIGURE 6 — CURRENT GAIN - BANDWIDTH PRODUCT



2

FIGURE 7 — ACTIVE REGION SAFE OPERATING AREA



MSD6100

CASE 29-02, STYLE 3
TO-92 (TO-226AA)

DUAL SWITCHING DIODE
COMMON CATHODE

2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	100	Vdc
Recurrent Peak Forward Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μsec)	$I_{FM(surge)}$	500	mA
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	625 5.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}(1)	−55 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	100	—	Vdc
Reverse Current	I_R			μAdc
(V_R = 100 Vdc)		—	5.0	
(V_R = 50 Vdc)		—	0.1	
(V_R = 50 Vdc, T_A = 125°C)		—	20	
Forward Voltage	V_F			Vdc
(I_F = 1.0 mAdc)		0.55	0.7	
(I_F = 10 mAdc)		0.67	0.82	
(I_F = 100 mAdc)		0.75	1.1	
Capacitance (V_R = 0)	C	—	1.5	pF
Reverse Recovery Time (I_F = I_R = 10 mAdc, V_R = 5.0 Vdc, i_{rr} = 1.0 mAdc)	t_{rr}	—	4.0	ns

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = −65 to +150°C, θ_{JC} = 125°C/W.

2

MSD6102

CASE 29-02, STYLE 3
TO-92 (TO-226AA)

DUAL DIODE
COMMON CATHODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Recurrent Peak Forward Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μs)	$I_{FM(surge)}$	500	mA
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	625 5.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}(1)	−55 to +135	°C

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = −65 to +150°C, θ_{JC} = 125°C/W.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	70	—	Vdc
Reverse Current (V_R = 50 Vdc)	I_R	—	0.1	μAdc
Forward Voltage (I_F = 10 mAdc)	V_F	—	1.0	Vdc
Capacitance (V_R = 0)	C	—	3.0	pF
Reverse Recovery Time (I_F = I_R = 10 mAdc, V_R = 5.0 Vdc, i_{rr} = 1.0 mAdc)	t_{rr}	—	100	ns

MSD6150

CASE 29-02, STYLE 4
TO-92 (TO-226AA)

DUAL DIODE
COMMON ANODE

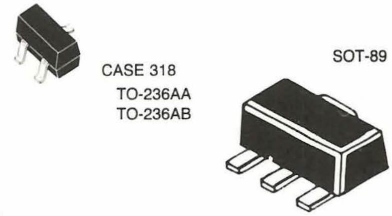
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Peak Forward Recurrent Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μs)	$I_{FM(surge)}$	500	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	625 5.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}(1)	−55 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	70	—	—	Vdc
Reverse Current (V_R = 50 Vdc)	I_R	—	—	0.1	μAdc
Forward Voltage (I_F = 10 mAdc)	V_F	—	0.80	1.0	Vdc
Capacitance (V_R = 0)	C	—	5.0	8.0	pF
Reverse Recovery Time (I_F = I_R = 10 mAdc, V_R = 5.0 Vdc, i_{rr} = 1.0 mAdc)	t_{rr}	—	—	100	ns

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 8.0 mW/°C, P_D = 10 W @ T_C = 25°C, Derate above 80 mW/°C, T_J, T_{stg} = −55 to +150°, θ_{JC} = 12.5°C/W, θ_{JA} = 125°C.



A wide variety of discrete components from Motorola's repertoire of reliability-proven semiconductor processes and geometries are available in the SOT-23 and SOT-89 packages. Products include Bipolar and Field-Effect Transistors, Switching, Zener and Varactor Diodes.

As an additional service to our customers SOT-23's are available in:

- 8 mm tape and reel
- reverse pinout
- standard profile (TO-236AA) or low profile (TO-236AB)

Contact your Motorola representative for ordering information.

Microminature Products

3

BCW29,30

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to 2N5086 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_E = 0)	$V_{(BR)CEO}$	20	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{EB} = 0)	$V_{(BR)CES}$	30	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_C = 0)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 100°C)	I_{CBO}	 — —	 100 10	 nAdc μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc) BCW29 BCW30	h_{FE}	 120 215	 260 500	 — —
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)	$V_{CE(sat)}$	—	0.3	Vdc
Base-Emitter On Voltage (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	0.6	0.75	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (I_E = 0, V_{CE} = 10 Vdc, f = 1.0 MHz)	C_{obo}	—	7.0	pF
Noise Figure (I_C = 0.2 mAdc, V_{CE} = 5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz, BW = 200 Hz)	NF	—	10	dB

BCW31,32,33

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to MPS3904 for graphs.

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 2.0$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	20	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_B = 0$)		$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 5.0$ Vdc)	 BCW31 BCW32 BCW33	h_{FE}	 110 200 420	 220 450 800	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 0.5$ mAdc)		$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter On Voltage ($I_C = 2.0$ mAdc, $V_{CE} = 5.0$ Vdc)		$V_{BE(on)}$	0.55	0.70	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance ($I_E = 0$, $V_{CB} = 10$ Vdc, f = 1.0 MHz)		C_{obo}	—	4.0	pF
Noise Figure ($I_C = 0.2$ mAdc, $V_{CE} = 5.0$ Vdc, $R_S = 2.0$ kΩ, f = 1.0 kHz, BW = 200 Hz)		NF	—	10	dB

BCW60A,B,C,D

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to MPS3904 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	32	Vdc
Collector-Base Voltage	V_{CBO}	32	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_E = 0)	$V_{(BR)CEO}$	32	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current	I_{CES}			
(V_{CE} = 32 Vdc)		—	20	nAdc
(V_{CE} = 32 Vdc, T_A = 150°C)		—	20	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	20	nAdc
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			—
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc) BCW60A		—	—	
BCW60B		20	—	
BCW60C		40	—	
BCW60D		100	—	
(I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc) BCW60A		120	220	
BCW60B		180	310	
BCW60C		250	460	
BCW60D		380	630	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc) BCW60A		60	—	
BCW60B		70	—	
BCW60C		90	—	
BCW60D		100	—	
(I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz) BCW60A		125	250	
BCW60B		175	350	
BCW60C		250	500	
BCW60D		350	700	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 1.25 mAdc)		—	0.55	
(I_C = 10 mAdc, I_B = 0.25 mAdc)		—	0.35	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 1.25 mAdc)		0.7	1.05	
(I_C = 50 mAdc, I_B = 0.25 mAdc)		0.6	0.85	
Base-Emitter On Voltage (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	0.55	0.75	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 MHz)	f_T	125	—	MHz
Output Capacitance (V_{CE} = 10 Vdc, I_C = 0, f = 1.0 MHz)	C_{obo}	—	4.5	pF
Noise Figure (I_C = 0.2 mAdc, V_{CE} = 5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz, BW = 200 Hz)	NF	—	6.0	dB
SWITCHING CHARACTERISTICS				
Turn-On Time (I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_{on}	—	150	ns
Turn-Off Time (I_{B2} = 1.0 mAdc, V_{BB} = 3.6 Vdc, R_1 = R_2 = 5.0 kΩ, R_L = 990 Ω)	t_{off}	—	800	ns

3

BCW61A,B,C,D

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to 2N5086 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	32	Vdc
Collector-Base Voltage	V_{CBO}	32	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	32	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 32 Vdc) (V_{CE} = 32 Vdc, T_A = 150°C)		I_{CES}	 — —	 20 20	 nAdc μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	 BCW61A BCW61B BCW61C BCW61D	h_{FE}	 — 20 40 100	 — — — —	—
(I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	BCW61A BCW61B BCW61C BCW61D		120 140 250 380	220 310 460 630	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	BCW61A BCW61B BCW61C BCW61D		60 80 100 100	— — — —	
(I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	BCW61A BCW61B BCW61C BCW61D		125 175 250 350	250 350 500 700	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 1.25 mAdc) (I_C = 10 mAdc, I_B = 0.25 mAdc)		$V_{CE(sat)}$	 — —	 0.55 0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 1.25 mAdc) (I_C = 10 mAdc, I_B = 0.25 mAdc)		$V_{BE(sat)}$	 0.68 0.6	 1.05 0.85	Vdc
Base-Emitter On Voltage (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	0.6	0.75	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CE} = 10 Vdc, I_C = 0, f = 1.0 MHz)	C_{obo}	—	6.0	pF
Noise Figure (I_C = 0.2 mAdc, V_{CE} = 5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz, BW = 200 Hz)	NF	—	6.0	dB
SWITCHING CHARACTERISTICS				
Turn-On Time (I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_{on}	—	150	ns
Turn-Off Time (I_{B2} = 1.0 mAdc, V_{BB} = 3.6 Vdc, R_1 = R_2 = 5.0 kΩ, R_L = 990 Ω)	t_{off}	—	800	ns

3

BCW65A

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	32	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	800	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	32	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{EB} = 0)	$V_{(BR)CES}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 32 Vdc, I_E = 0) (V_{CE} = 32 Vdc, I_E = 0, T_A = 150°C)	I_{CES}	 — —	 — —	 20 20	 nAdc μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	—	20	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	 35 75 100 35	 — — — —	 — 220 250 —	—
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	 — —	 0.7 0.3	 — —	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	—	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	100	—	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	—	12	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	—	80	pF
Noise Figure (I_C = 0.2 mAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kΩ, f = 1.0 kHz, BW = 200 Hz)	NF	—	—	10	dB
SWITCHING CHARACTERISTICS					
Turn-On Time (I_{B1} = I_{B2} = 15 mAdc)	t_{on}	—	—	100	ns
Turn-Off Time (I_C = 150 mAdc, R_L = 150 Ω)	t_{off}	—	—	400	ns

BCW66F

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CBO}	75	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	800	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	45	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10$ μAdc, $V_{EB} = 0$)	$V_{(BR)CES}$	75	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 45$ Vdc, $I_C = 0$) ($V_{CE} = 45$ Vdc, $I_C = 0$, $T_A = 150°C$)	I_{CES}	 — —	 — —	 20 20	 nAdc μAdc
Emitter Cutoff Current ($V_{EB} = 4.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	20	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 100$ μAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 500$ mAdc, $V_{CE} = 2.0$ Vdc)	h_{FE}	 35 75 100 35	 — — — —	 — — 250 —	—
Collector-Emitter Saturation Voltage ($I_C = 500$ mAdc, $I_B = 50$ mAdc) ($I_C = 100$ mAdc, $I_B = 10$ mAdc)	$V_{CE(sat)}$	 — —	 0.7 0.3	 — —	Vdc
Base-Emitter Saturation Voltage ($I_C = 500$ mAdc, $I_B = 50$ mAdc)	$V_{BE(sat)}$	—	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 20$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	100	—	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	—	12	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)	C_{ibo}	—	—	80	pF
Noise Figure ($I_C = 0.2$ mAdc, $V_{CE} = 5.0$ Vdc, $R_S = 1.0$ kΩ, f = 1.0 kHz, BW = 200 Hz)	NF	—	—	10	dB
SWITCHING CHARACTERISTICS					
Turn-On Time ($I_{B1} = I_{B2} = 15$ mAdc)	t_{on}	—	—	100	ns
Turn-Off Time ($I_C = 150$ mAdc, $R_L = 150$ Ω)	t_{off}	—	—	400	ns

BCW67,A,B,C
BCW68,F,G

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

3

MAXIMUM RATINGS

Rating	Symbol	BCW67	BCW68	Unit
Collector-Emitter Voltage	V_{CEO}	32	45	Vdc
Collector-Base Voltage	V_{CBO}	45	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	800		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)	 BCW67 Series BCW68 Series	$V_{(BR)CEO}$	 32 45	 — —	 — —	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10$ μAdc, $V_{EB} = 0$)	 BCW67 Series BCW68 Series	$V_{(BR)CES}$	 45 60	 — —	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 32$ Vdc, $I_E = 0$) ($V_{CE} = 45$ Vdc, $I_E = 0$) ($V_{CE} = 32$ Vdc, $I_B = 0$, $T_A = 150°C$) ($V_{CE} = 45$ Vdc, $I_B = 0$, $T_A = 150°C$)	 BCW67 Series BCW68 Series BCW67 Series BCW68 Series	I_{CES}	 — — — —	 — — — —	 20 20 10 10	 nAdc μAdc
Emitter Cutoff Current ($V_{EB} = 4.0$ Vdc, $I_C = 0$)		I_{EBO}	—	—	20	nAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)	 BCW67,A,68,F BCW67B,68G BCW67C	h_{FE}	 75 120 180	 — — —	 — — —	—
($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)	BCW67,A,68,F BCW67B,68G BCW67C		100 160 250	— — —	250 400 630	
($I_C = 500$ mAdc, $V_{CE} = 1.0$ Vdc)	BCW67,A,68,F BCW67B,68G BCW67C		35 60 100	— — —	— — —	
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 10$ mAdc)		$V_{CE(sat)}$	—	—	0.3	Vdc
Base-Emitter Saturation Voltage ($I_C = 500$ mAdc, $I_B = 50$ mAdc)		$V_{BE(sat)}$	—	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product ($I_C = 20$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)		f_T	100	—	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	—	18	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)		C_{ibo}	—	—	80	pF
Noise Figure ($I_C = 0.2$ mAdc, $V_{CE} = 5.0$ Vdc, $R_S = 1.0$ kΩ, f = 1.0 kHz, BW = 200 Hz)		NF	—	—	10	dB

BCW69,70

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to 2N5086 for graphs.

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	45	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{EB} = 0)		$V_{(BR)CES}$	50	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 100°C)		I_{CBO}	 — —	 100 10	 nAdc μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	 BCW69 BCW70	h_{FE}	 120 215	 260 500	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)		$V_{CE(sat)}$	—	0.3	Vdc
Base-Emitter On Voltage (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	0.6	0.75	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (I_E = 0, V_{CB} = 10 Vdc, f = 1.0 MHz)		C_{obo}	—	7.0	pF
Noise Figure (I_C = 0.2 mAdc, V_{CE} = 5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz, BW = 200 Hz)		NF	—	10	dB

3

BCW71,72

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to MPS3904 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CBO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 2.0$ mAdc, $V_{EB} = 0$)	$V_{(BR)CEO}$	45	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 2.0$ mAdc, $V_{EB} = 0$)	$V_{(BR)CES}$	45	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	50	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$) ($V_{CB} = 20$ Vdc, $I_E = 0$, $T_A = 100°C$)	I_{CBO}	 — —	 — —	 100 10	 nAdc μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 5.0$ Vdc) BCW71 BCW72	h_{FE}	 110 200	 — —	 220 450	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 0.5$ mAdc) ($I_C = 50$ mAdc, $I_B = 2.5$ mAdc)	$V_{CE(sat)}$	 — —	 — 0.21	 0.25 —	Vdc
Base-Emitter Saturation Voltage ($I_C = 50$ mAdc, $I_B = 2.5$ mAdc)	$V_{BE(sat)}$	—	0.85	—	Vdc
Base-Emitter On Voltage ($I_C = 2.0$ mAdc, $V_{CE} = 5.0$ Vdc)	$V_{BE(on)}$	0.6	—	0.75	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc, f = 35 MHz)	f_T	—	300	—	MHz
Output Capacitance ($I_E = 0$, $V_{CE} = 10$ Vdc, f = 1.0 MHz)	C_{obo}	—	—	4.0	pF
Input Capacitance ($I_C = 0$, $V_{EB} = 0.5$ Vdc, f = 1.0 MHz)	C_{ibo}	—	9.0	—	pF
Noise Figure ($I_C = 0.2$ mAdc, $V_{CE} = 5.0$ Vdc, $R_S = 2.0$ kΩ, f = 1.0 kHz, BW = 200 Hz)	NF	—	—	10	dB

BCX17,18
PNP
BCX19,20
NPN

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

3

MAXIMUM RATINGS

Rating	Symbol	Value BCX17	Value BCX18	Unit
Collector-Emitter Voltage	V_{CEO}	45	25	Vdc
Collector-Base Voltage	V_{CBO}	50	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

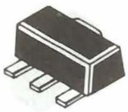
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)	BCX17 BCX18	$V_{(BR)CEO}$	45 25	— —	— —	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10$ μAdc, $I_C = 0$)	BCX17 BCX18	$V_{(BR)CES}$	50 30	— —	— —	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$) ($V_{CB} = 20$ Vdc, $I_E = 0$, $T_A = 150°C$)		I_{CBO}	— —	— —	100 5.0	nAdc μAdc
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$)		I_{EBO}	—	—	10	μAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 300$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 500$ mAdc, $V_{CE} = 1.0$ Vdc)		h_{FE}	100 70 40	— — —	600 — —	—
Collector-Emitter Saturation Voltage ($I_C = 500$ mAdc, $I_B = 50$ mAdc)		$V_{CE(sat)}$	—	—	0.62	Vdc
Base-Emitter On Voltage ($I_C = 500$ mAdc, $V_{CE} = 1.0$ Vdc)		$V_{BE(on)}$	—	—	1.2	Vdc

3

BCX51
BCX52
BCX53

CASE 345-01, STYLE 1
SOT-89



GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	BCX51	BCX52	BCX53	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	80	V
Collector-Emitter Voltage	V_{CER}	45	60	100	V
Collector-Base Voltage	V_{CBO}	45	60	100	V
Emitter-Base Voltage	V_{EBO}	5.0	5.0	5.0	V
Base Current	I_B	0.1	0.1	0.1	A
Collector Current — Continuous	I_C	1.0	1.0	1.0	A
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

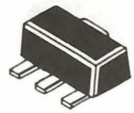
*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$			V
(I_C = 10 mA)	BCX51		45	—	
(I_C = 10 mA)	BCX52		60	—	
(I_C = 10 mA)	BCX53		80	—	
Collector-Base Breakdown Voltage		$V_{(BR)CBO}$			V
(I_C = 10 μA)	BCX51		45	—	
(I_C = 10 μA)	BCX52		60	—	
(I_C = 10 μA)	BCX53		100	—	
Emitter-Base Breakdown Voltage (I_E = 10 μA)		$V_{(BR)EBO}$	5.0	—	V
Collector Cutoff Current		I_{CBO}			
(V_{CB} = 30 V)			—	100	nA
(V_{CB} = 30 V, T_J = 125°C)			—	10	μA
Emitter Cutoff Current (V_{EB} = 3.0 V)		I_{EBO}	—	100	nA
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 5.0 mA, V_{CE} = 2.0 V)			25	—	
(I_C = 150 mA, V_{CE} = 2.0 V)	BCX51		40	250	
(I_C = 150 mA, V_{CE} = 2.0 V)	BCX52,53		40	160	
(I_C = 500 mA, V_{CE} = 2.0 V)			25	—	
Collector-Emitter Saturation Voltage (I_C = 500 mA, I_B = 50 mA)		$V_{CE(sat)}$	—	0.5	V
Base-Emitter On Voltage (I_C = 500 mA, V_{CE} = 2.0 V)		$V_{BE(on)}$	—	1.0	V
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (V_{CE} = 5.0 V, I_C = 10 mA, f = 35 MHz)		f_T	50	—	MHz

BCX54
BCX55
BCX56

CASE 345-01, STYLE 1
SOT-89



GENERAL PURPOSE TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	BCX54	BCX55	BCX56	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	80	V
Collector-Emitter Voltage	V_{CER}	45	60	100	V
Collector-Base Voltage	V_{CBO}	45	60	100	V
Emitter-Base Voltage	V_{EBO}	5.0	5.0	5.0	V
Base Current	I_B	0.1	0.1	0.1	A
Collector Current — Continuous	I_C	1.0	1.0	1.0	A

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

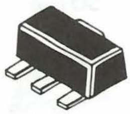
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$			V
(I_C = 10 mA)	BCX54		45	—	
(I_C = 10 mA)	BCX55		60	—	
(I_C = 10 mA)	BCX56		80	—	
Collector-Base Breakdown Voltage		$V_{(BR)CBO}$			V
(I_C = 10 μA	BCX54		45	—	
(I_C = 10 μA)	BCX55		60	—	
(I_C = 10 μA)	BCX56		100	—	
Emitter-Base Breakdown Voltage		$V_{(BR)EBO}$			V
(I_E = 500 mA, I_B = 50 mA)	BCX54		5.0	—	
(I_E = 10 μA)	BCX55		5.0	—	
(I_E = 10 μA)	BCX56		5.0	—	
Collector Cutoff Current		I_{CBO}			
(V_{CB} = 30 V)			—	100	nA
(V_{CB} = 30 V, T_J = 125°C)			—	10	μA
Emitter Cutoff Current (V_{EB} = 3.0 V)		I_{EBO}	—	100	nA
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 5.0 mA, V_{CE} = 2.0 V)			25	—	
(I_C = 150 mA, V_{CE} = 2.0 V)			40	250	
(I_C = 500 mA, V_{CE} = 2.0 V)			25	—	
Collector-Emitter Saturation Voltage (I_C = 500 mA, I_B = 50 mA)		$V_{CE(sat)}$	—	0.5	V
Base-Emitter On Voltage (I_C = 500 mA, V_{CE} = 2.0 V)		$V_{BE(on)}$	—	1.0	V
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (V_{CE} = 5.0 V, I_C = 10 mA, f = 35 MHz)		f_T	50	—	MHz

3

BCX68

CASE 345-01, STYLE 1
SOT-89



GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	V
Collector-Emitter Voltage	V_{CES}	25	V
Emitter-Base Voltage	V_{EBO}	5.0	V
Base Current	I_B	100	mA
Base Current — Maximum	I_{BM}	200	mA
Collector Current — Continuous	I_C	1.0	A
Collector Current — Maximum	I_{CM}	2.0	A

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mA)	$V_{(BR)CEO}$	20	—	V
Collector Cutoff Current (V_{CB} = = 25 V)	I_{CBO}	—	100	nA
Emitter Cutoff Current (V_{EB} = 5.0 V)	I_{EBO}	—	10	μA
ON CHARACTERISTICS				
DC Current Gain (V_{CE} = 10 V, I_C = 5.0 mA) (V_{CE} = 1.0 V, I_C = 0.5 A) (V_{CE} = 1.0 V, I_C = 1.0 A)	h_{FE}	 50 85 60	 — 375 —	—
Collector-Emitter Saturation Voltage (I_C = 1.0 A, I_B = 100 mA)	$V_{CE(sat)}$	—	0.5	V
Base-Emitter On Voltage (V_{CE} = 10 V, I_C = 5.0 mA) (V_{CE} = 1.0 V, I_C = 1.0 A)	$V_{BE(on)}$	 — —	 0.6 1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (V_{CE} = 5.0 V, I_C = 10 mA, f = 20 MHz)	f_T	65	—	MHz

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	V
Collector-Emitter Voltage	V_{CES}	25	V
Emitter-Base Voltage	V_{EBO}	5.0	V
Base Current	I_B	100	mA
Base Current — Maximum	I_{BM}	200	mA
Collector Current — Continuous	I_C	1.0	A
Collector Current — Maximum	I_{CM}	2.0	A

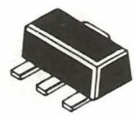
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

BCX69

CASE 345-01, STYLE 1
SOT-89



GENERAL PURPOSE TRANSISTOR

PNP SILICON

3

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 10$ mA)	$V_{(BR)CEO}$	20	—	V
Collector Cutoff Current ($V_{CB} = 25$ V)	I_{CBO}	—	100	nA
Emitter Cutoff Current ($V_{EB} = 5.0$ V)	I_{EBO}	—	10	μA
ON CHARACTERISTICS				
DC Current Gain ($V_{CE} = 10$ V, $I_C = 5.0$ mA) ($V_{CE} = 1.0$ V, $I_C = 0.5$ A) ($V_{CE} = 1.0$ V, $I_C = 1.0$ A)	h_{FE}	 50 85 60	 — 375 —	—
Collector-Emitter Saturation Voltage ($I_C = 1.0$ A, $I_B = 100$ mA)	$V_{CE(sat)}$	—	0.5	V
Base-Emitter On Voltage ($V_{CE} = 10$ V, $I_C = 5.0$ mA) ($V_{CE} = 1.0$ V, $I_C = 1.0$ A)	$V_{BE(on)}$	 — —	 0.6 1.0	V
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($V_{CE} = 5.0$ V, $I_C = 10$ mA, f = 20 MHz)	f_T	65	—	MHz

3

BCX70G,H,J,K

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to MPS3904 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CBO}	45	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_E = 0)		$V_{(BR)CEO}$	45	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 32 Vdc) (V_{CE} = 32 Vdc, T_A = 150°C)		I_{CES}	 — —	 20 20	 nAdc μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	—	20	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	 BCX70G BCX70H BCX70J BCX70K	h_{FE}	 — 20 40 100	 — — — —	—
(I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	BCX70G BCX70H BCX70J BCX70K		120 180 250 380	220 310 460 630	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	BCX70G BCX70H BCX70J BCX70K		60 70 90 100	— — — —	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 1.25 mAdc) (I_C = 10 mAdc, I_B = 0.25 mAdc)		$V_{CE(sat)}$	 — —	 0.55 0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 1.25 mAdc) (I_C = 50 mAdc, I_B = 0.25 mAdc)		$V_{BE(sat)}$	 0.7 0.6	 1.05 0.85	Vdc
Base-Emitter On Voltage (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	0.55	0.75	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	125	—	MHz
Output Capacitance (V_{CE} = 10 Vdc, I_C = 0, f = 1.0 MHz)		C_{obo}	—	4.5	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	BCX70G	h_{fe}	125	250	—
	BCX70H		175	350	
	BCX70J		250	500	
	BCX70K		350	700	
Noise Figure (I_C = 0.2 mAdc, V_{CE} = 5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz, BW = 200 Hz)		NF	—	6.0	dB
SWITCHING CHARACTERISTICS					
Turn-On Time (I_C = 10 mAdc, I_{B1} = 1.0 mAdc)		t_{on}	—	150	ns
Turn-Off Time (I_{B2} = 1.0 mAdc, V_{BB} = 3.6 Vdc, R1 = R2 = 5.0 kΩ, R_L = 990 Ω)		t_{off}	—	800	ns

3

BCX71G,H,J,K

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to 2N5086 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CBO}	45	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

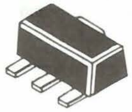
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 2.0$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	45	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 1.0$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 32$ Vdc) ($V_{CE} = 32$ Vdc, $T_A = 150°C$)		I_{CES}	 — —	 20 20	 nAdc μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc)	 BCX71G BCX71H BCX71J BCX71K	h_{FE}	 — 30 40 100	 — — — —	—
($I_C = 2.0$ mAdc, $V_{CE} = 5.0$ Vdc)	BCX71G BCX71H BCX71J BCX71K		120 140 250 380	220 310 460 630	
($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc)	BCX71G BCX71H BCX71J BCX71K		60 80 100 110	— — — —	
($I_C = 2.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz)	BCX71G BCX71H BCX71J BCX71K		125 175 250 350	250 350 500 700	
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 0.25$ mAdc) ($I_C = 50$ mAdc, $I_B = 1.25$ mAdc)		$V_{CE(sat)}$	 — —	 0.25 0.55	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 0.25$ mAdc) ($I_C = 50$ mAdc, $I_B = 1.25$ mAdc)		$V_{BE(sat)}$	 0.6 0.68	 0.85 1.05	Vdc
Base-Emitter On Voltage ($I_C = 2.0$ mAdc, $V_{CE} = 5.0$ Vdc)		$V_{BE(on)}$	0.6	0.75	Vdc
Output Capacitance ($V_{CE} = 10$ Vdc, $I_C = 0$, f = 1.0 MHz)		C_{obo}	—	6.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Noise Figure (I_C = 0.2 mAdc, V_{CE} = 5.0 Vdc, R_S = 2.0 kΩ, f = 1.0 kHz, BW = 200 Hz)	NF	—	6.0	dB
SWITCHING CHARACTERISTICS				
Turn-On Time (I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_{on}	—	150	ns
Turn-Off Time (I_{B2} = 1.0 mAdc, V_{BB} = 3.6 Vdc, R1 = R2 = 5.0 kΩ, R_L = 990 Ω)	t_{off}	—	800	ns

BFQ17

CASE 345-01, STYLE 1
SOT-89



RF TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	V
Collector-Emitter Voltage (RBE ≤ 50 Ω)	V_{CER}	40	V
Collector-Base Voltage	V_{CBO}	40	V
Emitter-Base Voltage	V_{EBO}	2.0	V
Collector Current — Continuous	I_C	300	mA
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

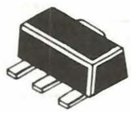
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mA)	$V_{(BR)CEO}$	25	—	V
Collector-Base Breakdown Voltage (I_C = 10 μA)	$V_{(BR)CBO}$	40	—	V
Emitter-Base Breakdown Voltage (I_E = 10 μA)	$V_{(BR)EBO}$	2.0	—	V
Collector Cutoff Current (V_{CB} = 20 V) (V_{CB} = 20 V, T_A = 150°C)	I_{CBO}	 — —	 100 20	nA
Emitter Cutoff Current (V_{EB} = 1.0 V)	I_{EBO}	—	100	nA
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mA, V_{CE} = 5.0 V) (I_C = 150 mA, V_{CE} = 5.0 V)	h_{FE}	 25 25	 — —	—
Collector-Emitter Saturation Voltage (I_C = 100 mA, I_B = 10 mA)	$V_{CE(sat)}$	—	0.5	V
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (V_{CE} = 15 V, I_C = 150 mA, f = 500 MHz)	f_T	1200(1)	—	MHz
Collector-Base Capacitance (V_{CB} = 15 V, f = 1.0 MHz)	C_{cb}	—	4.0	pF
Reverse Transfer Capacitance Common-Emitter (V_{CE} = 15 V, I_C = 10 mA, f = 1.0 MHz)	C_{re}	—	1.9	pF

(1) Typical only

BFQ18A

CASE 345-01, STYLE 1
SOT-89



RF TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	V
Collector-Base Voltage	V_{CBO}	25	V
Emitter-Base Voltage	V_{EBO}	12	V
Collector Current — Continuous	I_C	150	mA
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

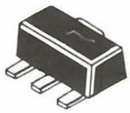
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mA)	$V_{(BR)CEO}$	15	—	V
Collector-Base Breakdown Voltage (I_C = 10 μA)	$V_{(BR)CBO}$	25	—	V
Emitter-Base Breakdown Voltage (I_E = 10 μA)	$V_{(BR)EBO}$	2.0	—	V
Collector Cutoff Current (V_{CB} = 10 V)	I_{CBO}	—	100	nA
Emitter Cutoff Current (V_{EB} = 1.0 V)	I_{EBO}	—	100	nA
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			—
(I_C = 50 mA, V_{CE} = 10 V)		25	—	
(I_C = 100 mA, V_{CE} = 10 V)		25	—	
SMALL SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (V_{CE} = 10 V, I_C = 50 mA, f = 500 MHz)	f_T	3200(1)	—	MHz

(1) Typical only

3

BFQ19

CASE 345-01, STYLE 1
SOT-89



RF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	V
Collector-Base Voltage	V_{CBO}	20	V
Emitter-Base Voltage	V_{EBO}	3.0	V
Collector Current Max (f > 1.0 MHz)	I_{CM}	150	mA
Collector Current — Average	I_{CAV}	75	mA
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mA)	$V_{(BR)CEO}$	15	—	V
Collector-Base Breakdown Voltage (I_C = 10 μA)	$V_{(BR)CBO}$	20	—	V
Emitter-Base Breakdown Voltage (I_E = 10 μA)	$V_{(BR)EBO}$	3.0	—	V
Collector Cutoff Current (V_{CB} = 10 V)	I_{CBO}	—	100	nA
Emitter Cutoff Current (V_{EB} = 1.0 V)	I_{EBO}	—	100	nA
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mA, V_{CE} = 10 V) (I_C = 75 mA, V_{CE} = 10 V)	h_{FE}	 25 25	 — —	—
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mA, V_{CE} = 10 V, f = 500 MHz) (I_C = 75 mA, V_{CE} = 10 V, f = 500 MHz)	f_T	 4.0 4.4	 — —	GHz
Collector-Base Capacitance (V_{CB} = 10 V, f = 1.0 MHz)	C_{cb}	—	1.6	pF
Capacitance Emitter-to-Base (V_{EB} = 0.5 V, f = 1.0 MHz)	C_{eb}	—	5.0	pF
Reverse Transfer Capacitance Common Emitter (V_{CE} = 10 V, I_C = 10 mA, f = 1.0 MHz)	C_{re}	—	1.3	pF
Noise Figure (I_C = 50 mA, V_{CE} = 10 V, f = 500 MHz)	NF	—	3.3	dB

BFR30,31

CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)

JFET
AMPLIFIER

N-CHANNEL

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate Reverse Current ($V_{GS} = 10$ Vdc, $V_{DS} = 0$)		I_{GSS}	—	0.2	nAdc
Gate Source Cutoff Voltage ($I_D = 0.5$ nAdc, $V_{DS} = 10$ Vdc)	 BFR30 BFR31	$V_{GS(off)}$	 — —	 5.0 2.5	Vdc
Gate Source Voltage ($I_D = 1.0$ mAdc, $V_{DS} = 10$ Vdc)	 BFR30 BFR31	V_{GS}	 0.7 —	 3.0 1.3	Vdc
($I_D = 50$ µAdc, $V_{DS} = 10$ Vdc)	BFR30 BFR31		— —	4.0 2.0	
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain ($V_{DS} = 10$ Vdc, $V_{GS} = 0$)	 BFR30 BFR31	I_{DSS}	 4.0 1.0	 10 5.0	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance ($I_D = 1.0$ mAdc, $V_{DS} = 10$ Vdc, f = 1.0 kHz)	 BFR30 BFR31	$\lvert Y_{fs} \rvert$	 1.0 1.5	 4.0 4.5	mAdc
($I_D = 200$ µAdc, $V_{DS} = 10$ Vdc, f = 1.0 kHz)	BFR30 BFR31		0.5 0.75	— —	
Output Admittance ($I_D = 1.0$ mAdc, $V_{DS} = 10$ Vdc, f = 1.0 kHz) ($I_D = 200$ µAdc, $V_{DS} = 10$ Vdc)	 BFR31 BFR31	$\lvert y_{os} \rvert$	 40 20	 25 15	µAdc
Input Capacitance ($I_D = 1.0$ mAdc, $V_{DS} = 10$ Vdc, f = 1.0 MHz) ($I_D = 200$ µAdc, $V_{DS} = 10$ Vdc, f = 1.0 MHz)		C_{iss}	 — —	 5.0 4.0	pF
Reverse Transfer Capacitance ($I_D = 1.0$ mAdc, $V_{DS} = 10$ Vdc, f = 1.0 MHz) ($I_D = 200$ µAdc, $V_{DS} = 10$ Vdc, f = 1.0 MHz)		C_{rss}	 — —	 1.5 1.5	pF

3

BFR92

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

RF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	2.0	Vdc
Collector Current — Continuous	I_C	25	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

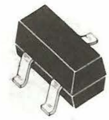
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mA)	$V_{(BR)CEO}$	15	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu A$)	$V_{(BR)CBO}$	20	—	Vdc
Emitter-Base Breakdown Voltage ($I_C = 100\ \mu A$)	$V_{(BR)EBO}$	2.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 10$ V)	I_{CBO}	—	50	nA
ON CHARACTERISTICS				
DC Current Gain ($I_C = 14$ mA, $V_{CE} = 10$ V)(1)	h_{FE}	25	—	—
Collector-Emitter Saturation Voltage(1) ($I_C = 25$ mA, $I_B = 5.0$ mA)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 25$ mA, $I_B = 5.0$ mA)	$V_{BE(sat)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 14$ mA, $V_{CE} = 10$ V, f = 500 MHz)	f_T	5 GHz (Typ)	—	MHz
Noise Figure ($V_{CE} = 1.5$ V, $I_C = 3.0$ mA, $R_S = 50\ \Omega$, f = 500 MHz)	NF	—	3.0 (Typ)	dB
Capacitance-Collector to Base ($V_{CB} = 10$ Vdc, f = 1.0 MHz)	C_{cb}	—	0.7 (Typ)	pF

(1) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

BFR93

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)



RF TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	15	Vdc
Emitter-Base Voltage	V_{EBO}	2.0	Vdc
Collector Current — Continuous	I_C	25	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 10$ mA)	$V_{(BR)CEO}$	12	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μA)	$V_{(BR)CBO}$	15	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μA)	$V_{(BR)EBO}$	2.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 10$ V)	I_{CEO}	—	50	nA
Collector Cutoff Current ($V_{CB} = 10$ V)	I_{CBO}	—	50	nA
Emitter Cutoff Current ($V_{EB} = 1.0$ V)	I_{EBO}	—	10	nA
ON CHARACTERISTICS				
DC Current Gain ($I_C = 1.0$ mA, $V_{CE} = 5.0$ V) ($I_C = 30$ mA, $V_{CE} = 5.0$ V)	h_{FE}	 25 25	 — —	—
Collector-Emitter Saturation Voltage ($I_C = 35$ mA, $I_B = 7.0$ mA)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 35$ mA, $I_B = 7.0$ mA)	$V_{BE(sat)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 30$ mA, $V_{CE} = 5.0$ V, f = 500 MHz)	f_T	4.5	—	GHz
Noise Figure ($V_{CE} = 5.0$ V, $I_C = 2.0$ mA, $R_S = 50$ Ω, f = 30 MHz)	NF	—	3.0	dB

3

BFS17

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

RF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 10$ mA)	$V_{(BR)CEO}$	15	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu A$)	$V_{(BR)CBO}$	25	—	Vdc
Collector Cutoff Current ($V_{CE} = 10$ V)	I_{CEO}	—	25	nA
Collector Cutoff Current ($V_{CB} = 10$ V)	I_{CBO}	—	25	nA
Emitter Cutoff Current ($V_{EB} = 4.0$ V)	I_{EBO}	—	100	μA
ON CHARACTERISTICS				
DC Current Gain ($I_C = 2.0$ mA, $V_{CE} = 1.0$ V) ($I_C = 25$ mA, $V_{CE} = 1.0$ V)	h_{FE}	 20 20	 150 —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mA, $I_B = 1.0$ mA)	$V_{CE(sat)}$	—	0.4	V
Base-Emitter Saturation Voltage ($I_C = 10$ mA, $I_B = 1.0$ mA)	$V_{BE(sat)}$	—	1.0	V
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 2.0$ mA, $V_{CE} = 5.0$ V, f = 500 MHz) ($I_C = 25$ mA, $V_{CE} = 5.0$ V, f = 500 MHz)	f_T	 1.0 1.3*	 — —	GHz
Output Capacitance ($V_{CB} = 10$ V, f = 1.0 MHz)	CCB	—	1.0*	pF
Noise Figure ($I_C = 2.0$ mA, $V_{CE} = 5.0$ V, $R_S = 50\ \Omega$, f = 30 MHz)	NF	—	5.0*	dB

*Typ

BSS63

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

HIGH VOLTAGE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	100	Vdc
Collector-Emitter Voltage R_{BE} = 10 kΩ	V_{CER}	110	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc)	$V_{(BR)CEO}$	100	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, I_E = 0, R_{BE} = 10 kΩ)	$V_{(BR)CER}$	110	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	110	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc)	$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 90 Vdc, I_E = 0)	I_{CBO}	—	—	100	nAdc
Collector Cutoff Current (V_{CE} = 110 Vdc, R_{BE} = 10 kΩ)	I_{CER}	—	—	10	μAdc
Emitter Cutoff Current (V_{EB} = 6.0 Vdc, I_C = 0)	I_{EBO}	—	—	200	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 25 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 30 30	 — —	 — —	—
Collector-Emitter Saturation Voltage (I_C = 25 mAdc, I_B = 2.5 mAdc)	$V_{CE(sat)}$	—	—	250	mVdc
Base-Emitter Saturation Voltage (I_C = 25 mAdc, I_B = 2.5 mAdc)	$V_{BE(sat)}$	—	—	900	mVdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 25 mAdc, V_{CE} = 5.0 Vdc, f = 35 MHz)	f_T	50	95	—	MHz
Case Capacitance (I_E = I_C = 0, V_{CB} = 10 Vdc)	C_c	—	—	5.0	pF

BSS64

CASE 318-03, STYLE 6
SOT-23 (TO-236AA/AB)

DRIVER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Base Voltage	V_{CBO}	120	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 4.0 mA)	$V_{(BR)CEO}$	80	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CBO}$	120	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μA)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 80 V, T_A = 70°C)	I_{CES}	—	20	μA
Emitter Cutoff Current (V_{BE} = 4.0 V)	I_{EBO}	—	200	nA
ON CHARACTERISTICS				
DC Current Gain (V_{CE} = 1.0 V, I_C = 10 mA)	h_{FE}	20	—	—
Collector-Emitter Saturation Voltage (I_C = 4.0 mA, I_B = 400 μA) (I_C = 50 mA, I_B = 15 mA)	$V_{CE(sat)}$	 — —	 0.7 3.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 4.0 mA, V_{CE} = 10 V, f = 35 MHz)	f_T	50	—	MHz

BSS79C

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	75	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc)	$V_{(BR)CBO}$	75	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc) (V_{CB} = 60 Vdc, T_A = 150°C)	I_{CBO}	 — —	 10 10	 nAdc μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc)	I_{EBO}	—	10	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 150 mAdc, V_{CE} = 10 Vdc)	h_{FE}	100	300	—
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	 — —	 0.3 1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (V_{CE} = 20 Vdc, I_C = 20 mAdc, f = 100 MHz)	f_T	250	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, f = 1.0 MHz)	C_{obo}	—	8.0	pF
SWITCHING CHARACTERISTICS				
Delay Time (V_{CC} = 30 Vdc, I_C = 150 mAdc) (I_{B1} = I_{B2} = 15 mAdc)	t_d	—	10	ns
Rise Time (V_{CC} = 30 Vdc, I_C = 150 mAdc) (I_{B1} = I_{B2} = 15 mAdc)	t_r	—	10	ns
Storage Time (V_{CC} = 30 Vdc, I_C = 150 mAdc) (I_{B1} = I_{B2} = 15 mAdc)	t_s	—	225	ns
Fall Time (V_{CC} = 30 Vdc, I_C = 150 mAdc) (I_{B1} = I_{B2} = 15 mAdc)	t_f	—	60	ns

3

BSS80C

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	800	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 10$ mA)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu A$)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu A$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc) ($V_{CB} = 50$ Vdc, $T_A = 150°C$)	I_{CBO}	 — —	 10 10	 nA µA
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc)	I_{EBO}	—	10	nA
ON CHARACTERISTICS				
DC Current Gain ($I_C = 150$ mA, $V_{CE} = 10$ Vdc)	h_{FE}	100	300	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mA, $I_B = 15$ mA) ($I_C = 500$ mA, $I_B = 50$ mA)	$V_{CE(sat)}$	 — —	 0.4 1.6	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 50$ mA, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	200	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, f = 1.0 MHz)	C_{obo}	—	8.0	pF

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
Delay Time	($I_{B1} \approx I_{B2} \approx 15$ mA, $V_{CC} = 30$ V, $I_C = 150$ mA)	t_d	—	10	ns
Rise Time		t_r	—	40	ns
Storage Time	($I_{B1} \approx I_{B2} \approx 15$ mA, $V_{CC} = 30$ V, $I_C = 150$ mA)	t_s	—	80	ns
Fall Time		t_f	—	30	ns

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

BSS82C

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 10$ mA)	$V_{(BR)CEO}$	60	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μA)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μA)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 50$ V) ($V_{CB} = 50$ V, $T_A = 150°C$)	I_{CBO}	 — —	 10 10	 nA μA
Emitter Cutoff Current ($V_{EB} = 3.0$ V)	I_{EBO}	—	10	nA
ON CHARACTERISTICS				
DC Current Gain ($I_C = 150$ mA, $V_{CE} = 10$ V)	h_{FE}	100	300	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mA, $I_B = 15$ mA) ($I_C = 500$ mA, $I_B = 50$ mA)	$V_{CE(sat)}$	 — —	 0.4 1.6	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 50$ mA, $V_{CE} = 20$ V, f = 200 MHz)	f_T	100	—	MHz

3

BSV52

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	20	Vdc
Collector Current — Continuous	I_C	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

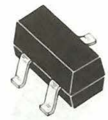
*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc)	$V_{(BR)CEO}$	12	—	Vdc
Collector Cutoff Current ($V_{CB} = 10$ Vdc, $I_E = 0$) ($V_{CB} = 10$ Vdc, $I_E = 0$, $T_A = 125°C$)	I_{CBO}	 — —	 100 5.0	nAdc μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	 25 40 25	 — 120 —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 300$ μAdc) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{CE(sat)}$	 — — —	 300 250 400	mVdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{BE(sat)}$	 700 —	 850 1200	mVdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	f_T	400	—	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	4.0	pF
Input Capacitance ($V_{EB} = 1.0$ Vdc, $I_C = 0$)	C_{ibo}	—	4.5	pF
SWITCHING CHARACTERISTICS				
Storage Time ($I_C = I_B = I_{BM} = 10$ mAdc)	t_s	—	13	ns
Turn-On Time ($V_{BE} = 1.5$ Vdc, $I_C = 10$ mAdc, $I_B = 3.0$ mAdc)	t_{on}	—	12	ns
Turn-Off Time ($I_C = 10$ mAdc, $I_B = 3.0$ mAdc)	t_{off}	—	18	ns

BSX39

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)



SWITCHING TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	14	Vdc
Collector Current — Continuous	I_C	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 2.0$ mA)	$V_{(BR)CEO}$	14	—	Vdc
Collector Cutoff Current ($V_{CB} = 12$ V)	I_{CBO}	—	100	nA
Collector Cutoff Current ($V_{CE} = 12$ V) ($V_{CE} = 12$ V, $T_J = 125°C$)	I_{CES}	 — —	 100 5.0	 nA μA
ON CHARACTERISTICS				
DC Current Gain ($I_C = 1.0$ mA, $V_{CE} = 1.0$ V) ($I_C = 10$ mA, $V_{CE} = 1.0$ V) ($I_C = 50$ mA, $V_{CE} = 1.0$ V)	h_{FE}	 25 40 25	 — 200 —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mA, $I_B = 1.0$ mA) ($I_C = 50$ mA, $I_B = 5.0$ mA)	$V_{CE(sat)}$	 — —	 250 400	mV
Base-Emitter Saturation Voltage ($I_C = 10$ mA, $I_B = 1.0$ mA) ($I_C = 50$ mA, $I_B = 5.0$ mA)	$V_{BE(sat)}$	 700 —	 850 1.2	 mV V
SWITCHING CHARACTERISTICS				
Turn-On Time ($I_C = 10$ mA, $I_B = 3.0$ mA)	t_{on}	—	12	ns
Turn-Off Time ($I_C = 10$ mA, $I_{B1} = I_{B2} = 3.0$ mA)	t_{off}	—	18	ns

3

BZX84C

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)

ZENER DIODES

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Voltage Range	$V_{Z(nom)}$	4.7 to 33	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Forward Voltage (I_F = 10 mAdc)	BZX84 Series	V_F	—	0.9	Vdc
Reverse Voltage Leakage Current		I_R			μAdc
(V_R = 2.0 Vdc)	BZX84-C4V7		—	3.0	
	BZX84-C5V1		—	2.0	
	BZX84-C5V6		—	1.0	
(V_R = 4.0 Vdc)	BZX84-C6V2		—	3.0	
	BZX84-C6V8		—	2.0	
(V_R = 5.0 Vdc)	BZX84-C7V5		—	1.0	
	BZX84-C8V2		—	0.7	
(V_R = 6.0 Vdc)	BZX84-C9V1		—	0.5	
(V_R = 7.0 Vdc)	BZX84-C10		—	0.2	
(V_R = 8.0 Vdc)	BZX84-C11, C12, C13		—	0.1	
(V_R = 0.70 V_Z)	BZX84-C15 to BZX84-C33		—	0.05	

ZENER VOLTAGE

Device	Marking	I_{Z3}(mA)	V_{Z3}(V) Min	V_{Z3}(V) Max	$Z_{ZT1}(\Omega)$	$Z_{ZT2}(\Omega)$	$Z_{ZT3}(\Omega)$	$\Delta V_Z/\Delta T$(nV/k) Min	$\Delta V_Z/\Delta T$(nV/k) Max
BZX84C4V7	Z1	20	4.4	5.1	80	500	15	−3.5	0.2
BZX84C5V1	Z2	20	4.8	5.5	60	480	15	−2.7	1.2
BZX84C5V6	Z3	20	5.2	6.3	40	400	10	−2.0	2.5
BZX84C6V2	Z4	20	5.8	6.8	10	150	6	0.4	3.7
BZX84C6V8	Z5	20	6.4	7.4	15	80	6	1.2	4.5
BZX84C7V5	Z6	20	7.0	8.0	15	80	6	2.5	5.3
BZX84C8V2	Z7	20	7.7	8.8	15	80	6	3.2	6.2
BZX84C9V1	Z8	20	8.5	9.7	15	100	8	3.8	7.0
BZX84C10	Z9	20	9.4	10.7	20	150	10	4.5	8.0
BZX84C11	Y1	20	10.4	11.8	20	150	10	5.4	9.0
BZX84C12	Y2	20	11.4	12.9	25	150	10	6.0	10
BZX84C13	Y3	20	12.5	14.2	30	170	15	7.0	11
BZX84C15	Y4	20	13.9	15.7	30	200	20	9.2	13
BZX84C16	Y5	20	15.4	17.2	40	200	20	10.4	14
BZX84C18	Y6	20	16.9	19.2	45	225	20	12.4	16
BZX84C20	Y7	20	18.9	21.4	55	225	20	14.4	18
BZX84C22	Y8	20	20.9	23.4	55	250	25	16.4	20
BZX84C24	Y9	20	22.9	25.7	70	250	25	18.4	22
BZX84C27	Y10	10	25.2	29.3	80	300	45	21.4	25.3
BZX84C30	Y11	10	28.1	32.4	80	300	50	24.4	29.4
BZX84C33	Y12	10	31.1	35.4	80	325	55	27.4	33.4

Device	Marking	I_{Z1}(mA)	V_{Z1}(V) Min	V_{Z1}(V) Max	I_{Z1}(mA)	V_{Z2}(V) Min	V_{Z2}(V) Max
BZX84C4V7	Z1	5	4.4	5.0	1	3.7	4.7
BZX84C5V1	Z2	5	4.8	5.4	1	4.2	5.3
BZX84C5V6	Z3	5	5.2	6.0	1	4.8	6.0
BZX84C6V2	Z4	5	5.8	6.6	1	5.6	6.6
BZX84C6V8	Z5	5	6.4	7.2	1	6.3	7.2
BZX84C7V5	Z6	5	7.0	7.9	1	6.9	7.9
BZX84C8V2	Z7	5	7.7	8.7	1	7.6	8.7
BZX84C9V1	Z8	5	8.5	9.6	1	8.4	9.6
BZX84C10	Z9	5	9.4	10.6	1	9.3	10.6
BZX84C11	Y1	5	10.4	11.6	1	10.2	11.6
BZX84C12	Y2	5	11.4	12.7	1	11.2	12.7
BZX84C13	Y3	5	12.4	14.1	1	12.3	14
BZX84C15	Y4	5	13.8	15.6	1	13.7	15.5
BZX84C16	Y5	5	15.3	17.1	1	15.2	17
BZX84C18	Y6	5	16.8	19.1	1	16.7	19
BZX84C20	Y7	5	18.8	21.2	1	18.7	21.1
BZX84C22	Y8	5	20.8	23.3	1	20.7	23.2
BZX84C24	Y9	5	22.8	25.6	1	22.7	25.5
BZX84C27	Y10	2	25.1	28.9	0.5	25	28.9
BZX84C30	Y11	2	28	32	0.5	27.8	32
BZX84C33	Y12	2	31	35	0.5	30.8	35

MBAL99

CASE 318-02/03, STYLE 18
SOT-23 (TO-236AA/AB)

SWITCHING DIODE

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Continuous Reverse Voltage	V_R	70	Vdc
Peak Forward Current	I_F	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

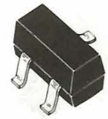
*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Voltage Leakage Current (V_R = 70 V) (V_R = 25 V, T_J = 150°C) (V_R = 70 V, T_J = 150°C)	I_R	 — — —	 2.5 30 50	μA
Reverse Breakdown Voltage (I_R = 100 μA)	$V_{(BR)}$	70	—	V
Forward Voltage (I_F = 1.0 mA) (I_F = 10 mA) (I_F = 50 mA) (I_F = 100 mA)	V_F	 — — — —	 715 855 1100 1300	mV
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_D	—	1.5	pF
Reverse Recovery Time ($I_F = I_R$ = 10 mA, R_L = 100 Ω, measured at I_R = 1.0 mA)	t_{rr}	—	15	ns
Forward Recovery Voltage (I_F = 10 mA, t_r = 20 ns)	V_{FR}	—	1.75	V

MBAS16

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)



SWITCHING DIODE

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Continuous Reverse Voltage	V_R	75	V_{CC}
Peak Forward Current	I_F	200	mA
Peak Forward Surge Current	$I_{FM(surge)}$	500	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Voltage Leakage Current ($V_R = 75$ V) ($V_R = 75$ V, $T_J = 150°C$) ($V_R = 25$ V, $T_J = 150°C$)	I_R	 — — —	 1.0 50 30	μA
Reverse Breakdown Voltage ($I_{BR} = 100$ μA)	$V_{(BR)}$	75	—	V
Forward Voltage ($I_F = 1.0$ mA) ($I_F = 10$ mA) ($I_F = 50$ mA) ($I_F = 100$ mA)	V_F	 — — — —	 715 855 1100 1300	mV
Diode Capacitance ($V_R = 0$, f = 1.0 MHz)	C_D	—	2.0	pF
Forward Recovery Voltage ($I_F = 10$ mA, $t_r = 20$ ns)	V_{FR}	—	1.75	V
Reverse Recovery Time ($I_F = I_R = 10$ mA, $R_L = 100\ \Omega$)	t_{rr}	—	15	ns
Stored Charge ($I_F = 10$ mA to $V_R = 5.0$ V, $R_L = 500\ \Omega$)	Q_S	—	45	pC

MBAV70

CASE 318-02/03, STYLE 9
SOT-23 (TO-236AA/AB)

SWITCHING DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mAdc

THERMAL CHARACTERISTICS

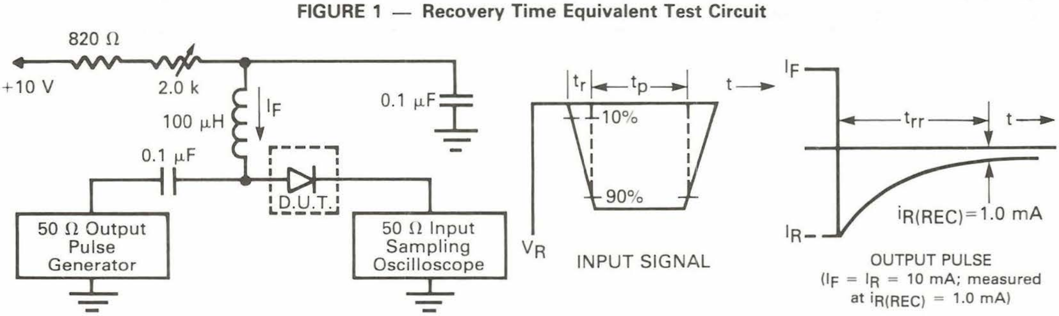
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	>70	—	Vdc
Reverse Voltage Leakage Current (V_R = 25 Vdc, T_J = 150°C) (V_R = 70 Vdc) (V_R = 70 Vdc, T_J = 150°C)	I_R	 — — —	 60 5.0 100	μAdc
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_T	—	1.5	pF
Forward Voltage (I_F = 1.0 mAdc) (I_F = 10 mAdc) (I_F = 50 mAdc) (I_F = 100 mAdc)	V_F	 — — — —	 715 855 1100 1300	mVdc
Reverse Recovery Time (I_F = i_R = 10 mAdc, V_R = 5.0 Vdc, $I_{R(REC)}$ = 1.0 mAdc) (Figure 1)	t_{rr}	—	15	ns

FIGURE 1 — Recovery Time Equivalent Test Circuit



Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

MBAV74

CASE 318-02/03, STYLE 9
SOT-23 (TO-236AA/AB)

SWITCHING DIODE

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	50	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)}$ = 5.0 μAdc)	$V_{(BR)}$	50	—	Vdc
Reverse Voltage Leakage Current (V_R = 50 Vdc, T_J = 125°C) (V_R = 50 Vdc)	I_R	 — —	 100 0.1	μAdc
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_T	—	2.0	pF
Forward Voltage (I_F = 100 mAdc)	V_F	—	1.0	Vdc
Reverse Recovery Time (I_F = I_R = 10 mAdc, $i_{R(REC)}$ = 1.0 mAdc, measured at I_R = 1.0 mA, R_L = 100 Ω)	t_{rr}	—	15	ns

MBAV99

CASE 318-02/03, STYLE 11
SOT-23 (TO-236AA/AB)

DUAL SERIES SWITCHING DIODE

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	100	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mAdc

THERMAL CHARACTERISTICS

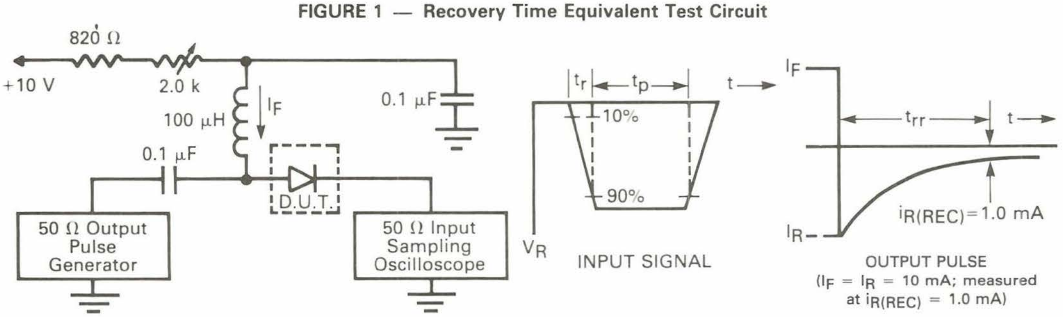
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)} = 100\ \mu A$)	$V_{(BR)}$	70	—	Vdc
Reverse Voltage Leakage Current ($V_R = 25$ Vdc, $T_J = 150°C$) ($V_R = 70$ Vdc) ($V_R = 70$ Vdc, $T_J = 150°C$)	I_R	 — — —	 30 2.5 50	μAdc
Diode Capacitance ($V_R = 0$, f = 1.0 MHz)	C_T	—	1.5	pF
Forward Voltage ($I_F = 1.0$ mAdc) ($I_F = 10$ mAdc) ($I_F = 50$ mAdc) ($I_F = 100$ mAdc)	V_F	 — — — —	 715 855 1100 1300	mVdc
Reverse Recovery Time ($I_F = I_R = 10$ mAdc, $i_{R(REC)} = 1.0$ mAdc) (Figure 1)	t_{rr}	—	15	ns

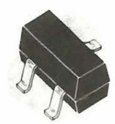
FIGURE 1 — Recovery Time Equivalent Test Circuit



Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

MBAW56

CASE 318-02/03, STYLE 12
SOT-23 (TO-236AA/AB)



DUAL SWITCHING DIODE

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	200	mAdc

THERMAL CHARACTERISTICS

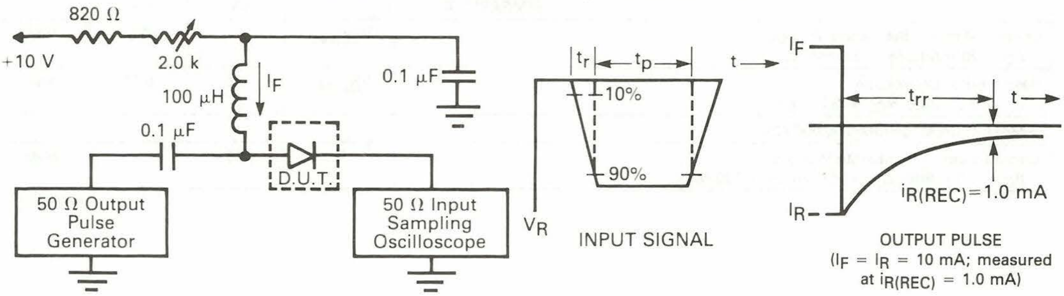
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	70	—	Vdc
Reverse Voltage Leakage Current (V_R = 25 Vdc, T_J = 150°C) (V_R = 70 Vdc) (V_R = 70 Vdc, T_J = 150°C)	I_R	 — — —	 30 2.5 50	μAdc
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_T	—	2.5	pF
Forward Voltage (I_F = 1.0 mAdc) (I_F = 10 mAdc) (I_F = 50 mAdc) (I_F = 100 mAdc)	V_F	 — — — —	 715 855 1100 1300	mVdc
Reverse Recovery Time (I_F = I_R = 10 mAdc, $I_{R(REC)}$ = 1.0 mAdc) (Figure 1)	t_{rr}	—	15	ns

FIGURE 1 — Recovery Time Equivalent Test Circuit



Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

3

MMBA811C5,6,7,8

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N5086 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CBO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

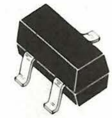
*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc)		$V_{(BR)CEO}$	45	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc)		$V_{(BR)CBO}$	50	—	Vdc
Emitter-Base Breakdown Voltage ($I_C = 10$ μAdc)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 40$ Vdc)		I_{CBO}	—	50	nAdc
Emitter Cutoff Current ($V_{EB} = 5.0$ Vdc)		I_{EBO}	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
($I_C = 0.1$ mAdc, $V_{CE} = 3.0$ Vdc)			150	—	
($I_C = 0.5$ mAdc, $V_{CE} = 3.0$ Vdc)			135	900	
(For Reference Only)			—	—	
($I_C = 0.5$ mAdc, $V_{CE} = 3.0$ Vdc)	MMBA811C5		135	270	
	MMBA811C6		200	400	
	MMBA811C7		300	600	
	MMBA811C8		450	900	
Collector-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		$V_{CE(sat)}$	—	0.3	Vdc
Base-Emitter On Voltage ($I_C = 0.5$ mAdc, $V_{CE} = 3.0$ Vdc)		$V_{BE(on)}$	0.5	0.65	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 1.0$ mAdc, $V_{CE} = 6.0$ Vdc, f = 100 MHz)		f_T	75	—	MHz

MMBA812M3,4,5,6,7

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)



GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to 2N5086 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector Cutoff Current ($V_{CB} = 40$ Vdc, $I_E = 0$)		I_{CBO}	—	0.1	μAdc
Emitter Cutoff Current ($V_{EB} = 5.0$ Vdc, $I_C = 0$)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain ($V_{CE} = 6.0$ Vdc, $I_C = 1.0$ mAdc)	 MMBA812M3 MMBA812M4 MMBA812M5 MMBA812M6 MMBA812M7	h_{FE}	 60 90 135 200 300	 120 180 270 400 600	—
Collector-Emitter Saturation Voltage ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage ($V_{CE} = 6.0$ Vdc, $I_C = 1.0$ mAdc)		$V_{BE(on)}$	—	0.8	Vdc

MMBC1009F1 thru MMBC1009F5

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

AM/FM RF AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

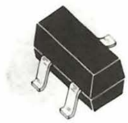
*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)		I_{CBO}	—	—	0.1	μAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = 0.5$ mAdc, $V_{CE} = 3.0$ Vdc)	MMBC1009F1 MMBC1009F2 MMBC1009F3 MMBC1009F4 MMBC1009F5	h_{FE}	30 40 60 90 135	— — — — —	60 80 120 180 270	
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)		$V_{CE(sat)}$	—	—	0.3	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product ($I_C = 1.0$ mAdc, $V_{CE} = 6.0$ Vdc, f = 100 MHz)		f_T	150	—	—	MHz
Output Capacitance ($V_{CB} = 6.0$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	2.0	—	pF
Noise Figure ($I_C = 0.5$ mAdc, $V_{CE} = 6.0$ Vdc, f = 1.0 MHz, $R_G = 500\ \Omega$)		NF	—	2.5	—	dB

MMBC1321Q2 thru MMBC1321Q5

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)



VHF/RF AMPLIFIER TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector Cutoff Current ($V_{CB} = 25$ Vdc, $I_E = 0$)		I_{CBO}	—	—	0.1	μAdc
Emitter Cutoff Current ($V_{EB} = 4.0$ Vdc, $I_C = 0$)		I_{EBO}	—	—	0.1	μAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 6.0$ Vdc)	 MMBC1321Q2 MMBC1321Q3 MMBC1321Q4 MMBC1321Q5	h_{FE}	 40 60 90 135	 — — — —	 80 120 180 270	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)		$V_{CE(sat)}$	—	—	0.6	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product ($I_C = 2.0$ mAdc, $V_{CE} = 6.0$ Vdc, f = 100 MHz)		f_T	600	—	—	MHz
Output Capacitance ($V_{CB} = 6.0$ Vdc, $I_E = 0$, f = 100 MHz)		C_{obo}	—	1.3	1.8	pF
Noise Figure ($V_{CE} = 6.0$ Vdc, $I_E = 2.0$ mAdc, f = 900 MHz, $R_G = 50\ \Omega$)		NF	—	5.0	—	dB

3

MMBC1621B2,3,4

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

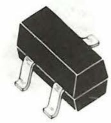
*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu A$)		$V_{(BR)CES}$	20	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu A$)		$V_{(BR)CBO}$	25	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu A$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ V)		I_{CBO}	—	100	nA
Emitter Cutoff Current ($V_{EB} = 4.0$ V)		I_{EBO}	—	100	nA
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
($I_C = 1.0$ mA, $V_{CE} = 0.5$ V)	MMBC1621B2		40	80	
($I_C = 1.0$ mA, $V_{CE} = 0.5$ V)	MMBC1621B3		60	120	
($I_C = 1.0$ mA, $V_{CE} = 0.5$ V)	MMBC1621B4		90	180	
Collector-Emitter Saturation Voltage ($I_C = 10$ mA, $I_B = 1.0$ mA)		$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mA, $I_B = 1.0$ mA)		$V_{BE(sat)}$	—	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mA, $V_{CE} = 10$ V, f = 100 MHz)		f_T	200	—	MHz
Output Capacitance ($V_{CB} = 10$ V, f = 1.0 MHz)		C_{obo}	—	5.0	pF
SWITCHING CHARACTERISTICS					
Storage Time ($I_C = I_{B1} = I_{B2} = 10$ mA) (Figure 1)		t_s	—	20	ns
Turn-On Time ($I_C = 10$ mA, $I_{B1} = 3.0$ mA, $V_{OB} = 1.5$ V)		t_{on}	—	20	ns
Turn-Off Time ($I_C = 10$ mA, $I_{B1} = 3.0$ mA, $I_{B2} = 1.5$ mA)		t_{off}	—	40	ns

MMBC1622D6,7,8

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)



AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MPS3904 for graphs.

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)		I_{CBO}	—	50	nAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (V_{CE} = 3.0 Vdc, I_C = 0.1 mAdc) (V_{CE} = 3.0 Vdc, I_C = 0.5 mAdc)	 All MMBC1622D6 MMBC1622D7 MMBC1622D8	h_{FE}	 150 200 300 450	 — 400 600 900	—
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{CE(sat)}$	—	0.3	Vdc
Base-Emitter On Voltage (V_{CE} = 3.0 Vdc, I_C = 0.5 mAdc)		$V_{BE(on)}$	0.55	0.65	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (V_{CE} = 6.0 Vdc, I_E = 1.0 mAdc, f = 100 Mhz)		f_T	100	—	MHz

MMBC1623L3,4,5,6,7

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MPS3904 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector Cutoff Current ($V_{CB} = 40$ Vdc, $I_E = 0$)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{EB} = 5.0$ Vdc, $I_C = 0$)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 6.0$ Vdc)	MMBC1623L3 MMBC1623L4 MMBC1623L5 MMBC1623L6 MMBC1623L7	h_{FE}	60 90 135 200 300	120 180 270 400 600	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 10$ mAdc)		$V_{CE(sat)}$	—	0.3	Vdc
Base-Emitter Saturation Voltage ($I_C = 100$ mA, $I_B = 10$ mAdc)		$V_{BE(sat)}$	—	1.0	Vdc
Base-Emitter On Voltage ($I_C = 1.0$ mAdc, $V_{CE} = 6.0$ Vdc)		$V_{BE(on)}$	.60	0.7	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($V_{CE} = 6.0$ Vdc, $I_E = 10$ mAdc, f = 100 MHz)		f_T	200	—	MHz

MMBC1653N2,3,4

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

3

HIGH VOLTAGE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	130	Vdc
Collector-Base Voltage	V_{CBO}	150	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector Cutoff Current (V_{CB} = 100 Vdc, I_E = 0)		I_{CBO}	—	—	0.1	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	—	—	0.1	μAdc
ON CHARACTERISTICS						
DC Current Gain (V_{CE} = 3.0 Vdc, I_C = 15 mAdc)	 MMBC1653N2 MMBC1653N3 MMBC1653N4	h_{FE}	 50 100 150	 — — —	 130 220 330	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	—	—	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	—	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (V_{CE} = 10 Vdc, I_E = 10 mAdc, f = 100 MHz)		f_T	—	150	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	4.5	—	pF

3

MMBC1654N5,6,7

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

HIGH VOLTAGE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	160	Vdc
Collector-Base Voltage	V_{CBO}	180	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

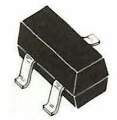
*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector Cutoff Current ($V_{CB} = 100$ V, $I_E = 0$)		I_{CBO}	—	—	0.1	μAdc
Emitter Cutoff Current ($V_{EB} = 5.0$ Vdc, $I_C = 0$)		I_{EBO}	—	—	0.1	μAdc
ON CHARACTERISTICS						
DC Current Gain ($V_{CE} = 3.0$ V, $I_C = 15$ mAdc)	MMBC1654N5 MMBC1654N6 MMBC1654N7	h_{FE}	50 100 150	— — —	130 220 330	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)		$V_{CE(sat)}$	—	—	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)		$V_{BE(sat)}$	—	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product ($V_{CE} = 10$ Vdc, $I_F = 10$ mAdc, f = 100 MHz)		f_T	—	150	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	4.5	—	pF

MMBD101

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)



HOT-CARRIER
UHF MIXER DIODE

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)}$	4.0	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 3.0 Vdc)	I_R	—	—	0.25	μAdc
Series Inductance (f = 250 MHz)	L_S	—	6.0	—	nH
Case Capacitance (f = 1.0 MHz)	C_C	—	0.18	—	pF
Diode Capacitance (V_R = 0, f = 1.0 MHz)	C_T	—	—	1.0	pF
Forward Voltage (I_F = 10 mAdc)	V_F	—	—	0.60	Vdc
Noise Figure (f = 1.0 GHz)	NF	—	—	7.0	dB

MMBD352

CASE 318-02/03 STYLE 11
SOT-23 (TO-236AA/AB)

DUAL HOT CARRIER
MIXER DIODE

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Continuous Reverse Voltage	V_R	4	V_{CC}

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Forward Voltage ($I_F = 10$ mA)	V_F	—	0.60	V
Reverse Voltage Leakage Current ($V_R = 3.0$ V) ($V_R = 4.0$ V)	I_R	 — —	 0.25 10	μA
Capacitance ($V_R = 0$ V, f = 1.0 MHz)	C	—	1.0	pF

MMBD501

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)

HOT-CARRIER DIODE

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	50	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Reverse Breakdown Voltage ($I_R = 10\ \mu Adc$)	$V_{(BR)}$	50	—	—	Vdc
Reverse Voltage Leakage Current ($V_R = 25$ Vdc)	I_R	—	—	200	μAdc
Diode Capacitance ($V_R = 20$ Vdc, f = 1.0 MHz)	C_T	—	—	1.0	pF
Forward Voltage ($I_F = 10$ mAdc)	V_F	—	—	1.2	Vdc

MMBD914X

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)

HIGH-SPEED SWITCHING DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mAdc

THERMAL CHARACTERISTICS

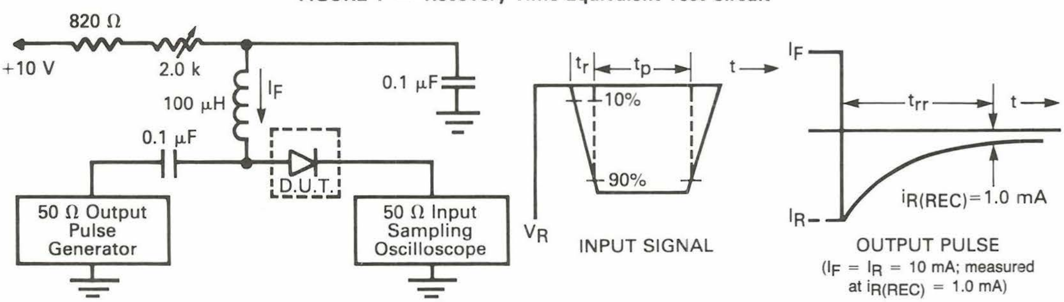
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_R = 100$ μAdc)	$V_{(BR)}$	100	—	Vdc
Reverse Voltage Leakage Current ($V_R = 20$ Vdc) ($V_R = 75$ Vdc)	I_R	 — —	 25 5.0	 nAdc μAdc
Diode Capacitance ($V_R = 0$ Vdc, f = 1.0 MHz)	C_T	—	4.0	pF
Forward Voltage ($I_F = 10$ mAdc)	V_F	—	1.0	Vdc
Reverse Recovery Time ($I_F = I_R = 10$ mAdc) (Figure 1)	t_{rr}	—	15	ns

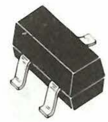
FIGURE 1 — Recovery Time Equivalent Test Circuit



Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

MMBD2835X36X

CASE 318-02/03, STYLE 12
SOT-23 (TO-236AA/AB)



DUAL SWITCHING DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	100	mAdc

THERMAL CHARACTERISTICS

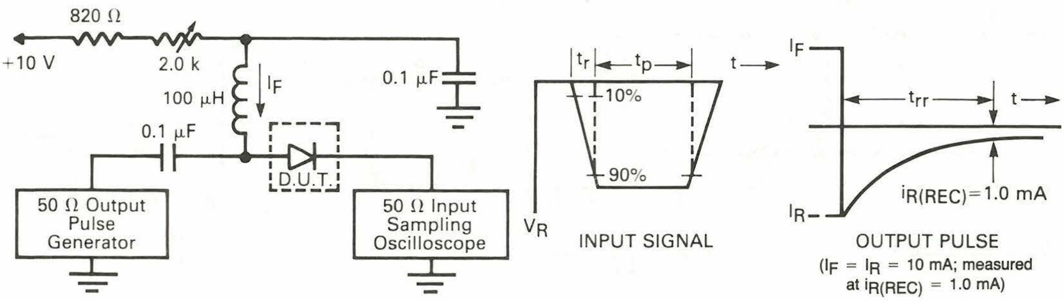
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Reverse Breakdown Voltage ($I_R = 100\ \mu Adc$)	 MMBD2835X MMBD2836X	$V_{(BR)}$	 35 75	 — —	Vdc
Reverse Voltage Leakage Current ($V_R = 30$ Vdc) ($V_R = 50$ Vdc)	 MMBD2835X MMBD2836X	I_R	 — —	 100 100	nAdc
Diode Capacitance ($V_R = 0$, f = 1.0 MHz)		C_T	—	4.0	pF
Forward Voltage ($I_F = 10$ mAdc) ($I_F = 50$ mAdc) ($I_F = 100$ mAdc)		V_F	 — — —	 1.0 1.0 1.2	Vdc
Reverse Recovery Time ($I_F = I_R = 10$ mAdc, $i_{R(REC)} = 1.0$ mAdc) (Figure 1)		t_{rr}	—	15	ns

FIGURE 1 — Recovery Time Equivalent Test Circuit



Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

MMBD2837X
MMBD2838X

CASE 318-02/03, STYLE 9
SOT-23 (TO-236AA/AB)

DUAL SWITCHING DIODE

3

MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Peak Reverse Voltage		V_{RM}	75	Vdc
D.C. Reverse Voltage	MMBD2837 MMBD2838	V_R	30 50	Vdc
Peak Forward Current		I_{FM}	450 300	mAdc
Average Rectified Current		I_O	150 100	mAdc

THERMAL CHARACTERISTICS

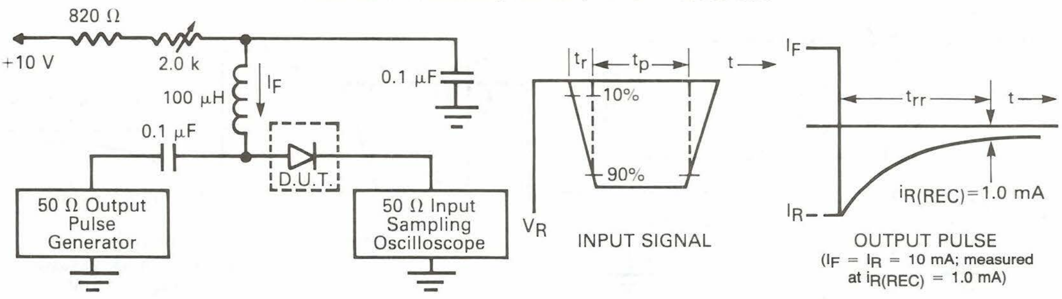
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Reverse Breakdown Voltage ($I_{(BR)} = 100\ \mu Adc$)	 MMBD2837X MMBD2838X	$V_{(BR)}$	 35 75	 — —	Vdc
Reverse Voltage Leakage Current ($V_R = 30$ Vdc) ($V_R = 50$ Vdc)	 MMBD2837X MMBD2838X	I_R	 — —	 0.1 0.1	µAdc
Diode Capacitance ($V_R = 0$, f = 1.0 MHz)		C_T	—	4.0	pF
Forward Voltage ($I_F = 10$ mAdc) ($I_F = 50$ mAdc) ($I_F = 100$ mAdc)		V_F	 — — —	 1.0 1.0 1.2	Vdc
Reverse Recovery Time ($I_F = I_R = 10$ mAdc, $i_{R(REC)} = 1.0$ mAdc) (Figure 1)		t_{rr}	—	15	ns

FIGURE 1 — Recovery Time Equivalent Test Circuit



Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

MMBD6050X

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)

SWITCHING DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mAdc

THERMAL CHARACTERISTICS

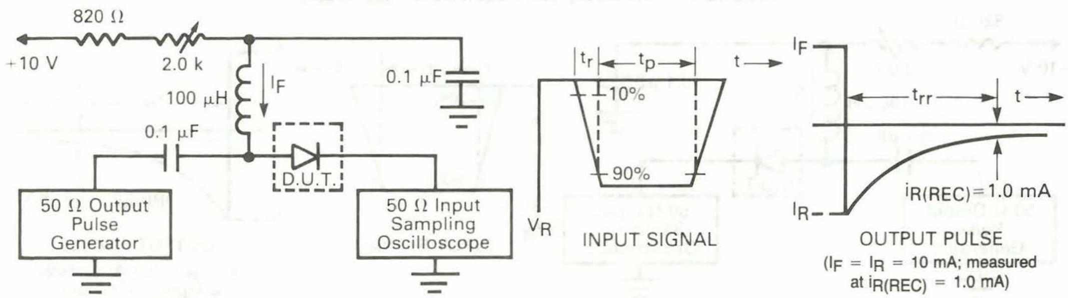
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	70	—	Vdc
Reverse Voltage Leakage Current (V_R = 50 Vdc)	I_R	—	0.1	μAdc
Forward Voltage (I_F = 1.0 mAdc) (I_F = 100 mAdc)	V_F	 0.55 0.85	 0.7 1.1	Vdc
Reverse Recovery Time ($I_F = I_R$ = 10 mAdc, $i_{R(REC)}$ = 1.0 mAdc) (Figure 1)	t_{rr}	—	15	ns
Capacitance (V_R = 0)	C	—	2.5	pF

FIGURE 1 — Recovery Time Equivalent Test Circuit



Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

3

MMBD6100

CASE 318-02/03, STYLE 9
SOT-23 (TO-236AA/AB)

DUAL
SWITCHING DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mAdc

THERMAL CHARACTERISTICS

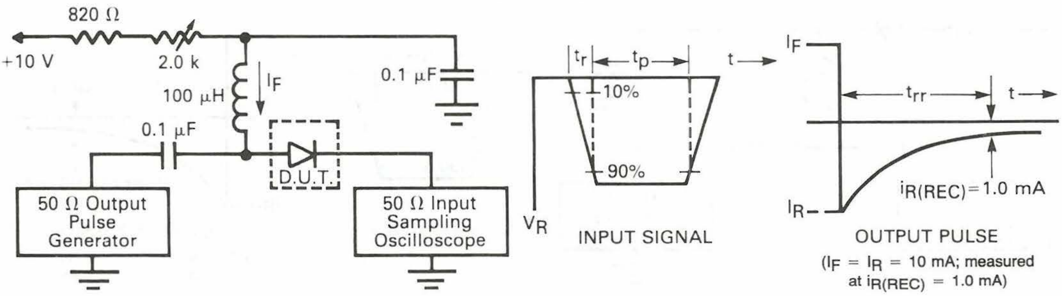
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	70	—	Vdc
Reverse Voltage Leakage Current (V_R = 50 Vdc)	I_R	—	0.1	μAdc
Forward Voltage (I_F = 1.0 mAdc) (I_F = 100 mAdc)	V_F	 0.55 0.85	 0.7 1.1	Vdc
Reverse Recovery Time ($I_F = I_R$ = 10 mAdc, $i_{R(REC)}$ = 1.0 mAdc) (Figure 1)	t_{rr}	—	15	ns
Capacitance (V_R = 0)	C	—	2.5	pF

FIGURE 1 — Recovery Time Equivalent Test Circuit



Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

MMBD7000

CASE 318-02/03, STYLE 11
SOT-23 (TO-236AA/AB)

DUAL SWITCHING DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	100	Vdc
Forward Current	I_F	200	mAdc
Peak Forward Surge Current	$I_{FM(surge)}$	500	mAdc

THERMAL CHARACTERISTICS

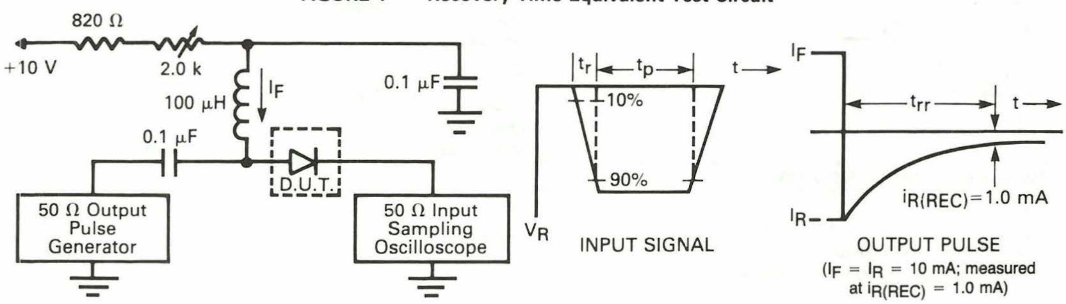
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Reverse Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	100	—	Vdc
Reverse Voltage Leakage Current (V_R = 50 Vdc) (V_R = 100 Vdc) (V_R = 50 Vdc, 125°C)	 I_R I_{R2} I_{R3}	 — — —	 0.30 0.5 100	μAdc
Forward Voltage (I_F = 1.0 mAdc) (I_F = 10 mAdc) (I_F = 100 mAdc)	V_F	 0.55 0.67 0.75	 0.7 0.82 1.1	Vdc
Reverse Recovery Time ($I_F = I_R$ = 10 mAdc) (Figure 1)	t_{rr}	—	15	ns
Capacitance (V_R = 0)	C	—	1.5	pF

FIGURE 1 — Recovery Time Equivalent Test Circuit



Notes: 1. A 2.0 kΩ variable resistor adjusted for a Forward Current (I_F) of 10 mA.
2. Input pulse is adjusted so $I_{R(peak)}$ is equal to 10 mA.
3. $t_p \gg t_{rr}$

3

MMBF4391 thru MMBF4393

CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)

JFET SWITCHING TRANSISTOR

N-CHANNEL

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Forward Gate Current	$I_{G(f)}$	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = 1.0\ \mu Adc$, $V_{DS} = 0$)		$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current ($V_{GS} = 15$ Vdc, $V_{DS} = 0$, $T_A = 25°C$) ($V_{GS} = 15$ Vdc, $V_{DS} = 0$, $T_A = 100°C$)		I_{GSS}	 — —	 1.0 0.20	 nAdc μAdc
Gate Source Cutoff Voltage ($V_{DS} = 15$ Vdc, $I_D = 10$ nAdc)	 MMBF4391 MMBF4392 MMBF4393	$V_{GS(off)}$	 4.0 2.0 0.5	 10 5.0 3.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain ($V_{DS} = 15$ V, $V_{GS} = 0$)	 MMBF4391 MMBF4392 MMBF4393	I_{DSS}	 50 25 5.0	 150 75 30	mAdc
Drain Current ($V_{DS} = 15$ Vdc, $V_{GS} = 12$ Vdc) ($V_{DS} = 15$, $V_{GS} = 12$ Vdc, $T_A = 100°C$)		I_D	 — —	 1.0 1.0	 nAdc μAdc
Drain-Source On-Voltage ($I_D = 12$ mAdc, $V_{GS} = 0$) ($I_D = 6.0$ mAdc, $V_{GS} = 0$) ($I_D = 3.0$ mAdc, $V_{GS} = 0$)	 MMBF4391 MMBF4392 MMBF4393	$V_{DS(on)}$	 — — —	 0.4 0.4 0.4	Vdc
Static Drain-Source On Resistance ($I_D = 1.0$ mAdc, $V_{GS} = 0$)	 MMBF4391 MMBF4392 MMBF4393	$r_{DS(on)}$	 — — —	 30 60 100	Ohms
SMALL-SIGNAL CHARACTERISTICS					
Input Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)		C_{iss}	—	14	pF
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = 12$ Vdc, f = 1.0 MHz)		C_{rss}	—	3.5	pF

MMBF4416

CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)

FET
VHF/UHF AMPLIFIER TRANSISTOR

N-CHANNEL

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Gate Current	I_G	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0) (V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 150°C)	I_{GSS}	 — —	 1.0 200	 nAdc nAdc
Gate Source Cutoff Voltage (I_D = 1.0 nAdc, V_{DS} = 15 Vdc)	$V_{GS(off)}$	—	6.0	Vdc
Gate Source Voltage (I_D = 0.5 mAdc, V_{DS} = 15 Vdc)	V_{GS}	1.0	5.5	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain (V_{GS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	5.0	15	mAdc
Gate-Source Forward Voltage (I_G = 1.0 mAdc, V_{DS} = 0)	$V_{GS(f)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|Y_{fs}\|$	4500	7500	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{os}\|$	—	50	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	4.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	0.8	pF
Output Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	2.0	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, R_g ≈ 1000 Ω, f = 100 MHz) (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, R_g ≈ 1000 Ω, f = 400 MHz)	NF	 — —	 2.0 4.0	dB
Common Source Power Gain (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 100 MHz) (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 400 MHz)	G_{ps}	 18 10	 — —	dB

MMBF4860

CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)

FET
SWITCHING TRANSISTOR

N-CHANNEL

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	30	Vdc
Forward Gate Current	$I_{G(f)}$	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

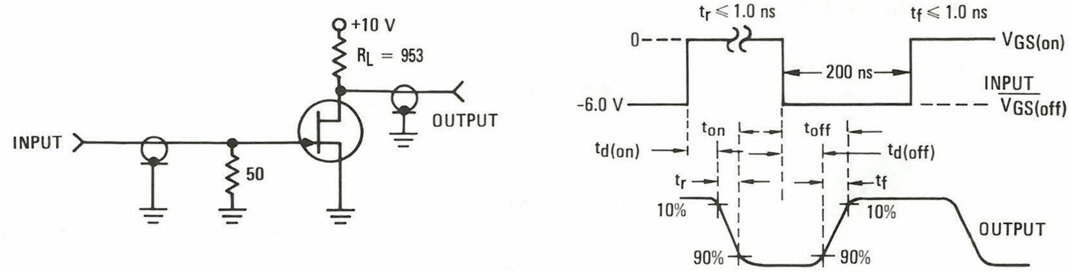
*Package mounted on 99.5% alumina 10 x x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0) (V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 150°C)	I_{GSS}	 — —	 0.5 2.0	 nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 0.5 nAdc)	$V_{GS(off)}$	2.0	6.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain(1) (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	20	100	mAdc
Drain Cutoff Current (V_{DS} = 15 Vdc, V_{GS} = 10 Vdc) (V_{DS} = 15 Vdc, V_{GS} = 10 Vdc, T_A = 150°C)	$I_{D(off)}$	 — —	 0.25 0.5	 nAdc μAdc
Drain-Source On-Voltage (I_D = 10 mAdc, V_{GS} = 0)	$V_{DS(on)}$	—	0.5	Vdc
Static Drain-Source On Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	$r_{DS(on)}$	—	40	Ohms
Input Capacitance (V_{DS} = 0, V_{GS} = 10 Vdc, f = 1.0 MHz)	C_{iss}	—	18	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 10 Vdc, f = 1.0 MHz)	C_{rss}	—	8.0	pF
SWITCHING CHARACTERISTICS				
Delay Time (V_{DD} = 10 Vdc, $I_{D(on)}$ = 20 mAdc) ($V_{G(on)}$ = 0, $V_{GS(off)}$ = 10 Vdc)	t_d	—	6.0	ns
Rise Time (V_{DD} = 10 Vdc, $I_{D(on)}$ = 10 mAdc) ($V_{GS(on)}$ = 0, $V_{GS(off)}$ = 6.0 Vdc) (Figure 1)	t_r	—	4.0	ns
Turn-Off Time (V_{DD} = 10 Vdc, $I_{D(on)}$ = 5.0 mAdc) ($V_{GS(on)}$ = 0, $V_{GS(off)}$ = 4.0 Vdc) (Figure 1)	t_{off}	—	50	ns

(1) Pulse Test: Pulse Width = 100 ms, Duty Cycle ≤ 10%.

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: 1. The input waveforms are supplied by a generator with the following characteristics:
Z_{out} = 50 ohms, Duty Cycle ≈ 2.0%
2. Waveforms are monitored on an oscilloscope with the following characteristics:
$t_r \leq 0.75$ ns, $R_{in} \geq 1.0$ megohm, $C_{in} \leq 2.5$ pF.

3

3

MMBF5457

CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)

FET
GENERAL PURPOSE TRANSISTOR

N-CHANNEL

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	25	Vdc
Gate Current	I_G	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = 10\ \mu Adc$, $V_{DS} = 0$)	$V_{(BR)GSS}$	25	—	—	Vdc
Gate Reverse Current ($V_{GS} = 15$ Vdc, $V_{DS} = 0$) ($V_{GS} = 15$ Vdc, $V_{DS} = 0$, $T_A = 100°C$)	I_{GSS}	 — —	 — —	 1.0 200	nAdc
Gate Source Cutoff Voltage ($V_{DS} = 15$ Vdc, $I_D = 10$ nAdc)	$V_{GS(off)}$	0.5	—	6.0	Vdc
Gate Source Voltage ($V_{DS} = 15$ Vdc, $I_D = 100\ \mu Adc$)	V_{GS}	—	2.5	—	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain(1) ($V_{DS} = 15$ Vdc, $V_{GS} = 0$)	I_{DSS}	1.0	—	5.0	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance(1) ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)	$\|Y_{fs}\|$	1000	—	5000	μmhos
Reverse Transfer Admittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)	$\|y_{rs}\|$	—	10	50	μmhos
Input Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)	C_{iss}	—	4.5	7.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)	C_{rss}	—	1.5	3.0	pF

(1) Pulse test: Pulse Width ≤ 630 ms; Duty Cycle ≤ 10%.

MMBF5459

CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)

FET TRANSISTOR

N-CHANNEL

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	−25	Vdc
Gate Current	I_G	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = -10\ \mu A$, $V_{DS} = 0$)	$V_{(BR)GSS}$	25	—	Vdc
Gate 1 Leakage Current ($V_{GS} = -15$ V, $V_{DS} = 0$)	I_{G1SS}	—	1.0	nA
Gate 2 Leakage Current ($V_{GS} = -15$ V, $V_{DS} = 0$, $T_A = 100°C$)	I_{G2SS}	—	200	nA
Gate Source Cutoff Voltage ($V_{DS} = 15$ V, $I_D = 10$ nA)	$V_{GS(off)}$	2.0	8.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain ($V_{DS} = 15$ V, $V_{GS} = 0$)	I_{DSS}	4.0	16	mA
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance ($V_{DS} = 15$ V, $V_{GS} = 0$, f = 1.0 kHz)	$\|Y_{fs}\|$	2000	6000	µmhos
Output Admittance ($V_{DS} = 15$ V, $V_{GS} = 0$, f = 1.0 kHz)	$\|Y_{os}\|$	—	50	µmhos
Input Capacitance ($V_{DS} = 15$ V, $V_{GS} = 0$, f = 1.0 MHz)	C_{iss}	—	7.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ V, $V_{GS} = 0$, f = 1.0 MHz)	C_{rss}	—	3.0	pF

3

MMBF5460

CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)

FET
GENERAL PURPOSE
TRANSISTOR

P-CHANNEL

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	40	Vdc
Reverse Gate-Source Voltage	V_{GSR}	40	Vdc
Forward Gate Current	I_{GF}	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	40	—	—	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0) (V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 100°C)	I_{GSS}	 — —	 — —	 5.0 1.0	 nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 1.0 μAdc)	$V_{GS(off)}$	0.75	—	6.0	Vdc
Gate Source Voltage (V_{DS} = 15 Vdc, I_D = 0.1 mAdc)	V_{GS}	0.5	—	4.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	1.0	—	5.0	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|Y_{fs}\|$	1000	—	4000	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|Y_{os}\|$	—	—	75	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	5.0	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	1.0	2.0	pF
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 MΩ, f = 100 Hz, BW = 1.0 Hz)	$\bar{e}_n$	—	20	—	nV/$\sqrt{Hz}$

MMBF5484

CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)

FET TRANSISTOR

N-CHANNEL

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	25	Vdc
Forward Gate Current	$I_{G(f)}$	10	mA
Continuous Device Dissipation at or Below T_C = 25°C Linear Derating Factor	P_D	200 2.80	mW mW/°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = −1.0 μA, V_{DS} = 0)	$V_{(BR)GSS}$	−25	—	Vdc
Gate Reverse Current (V_{GS} = −20 V, V_{DS} = 0) (V_{GS} = −20 V, V_{DS} = 0, T_A = 100°C)	I_{GSS}	 — —	 −1.0 −0.2	 nA μA
Gate Source Cutoff Voltage (V_{DS} = 15 V, I_D = 10 nA)	$V_{GS(off)}$	−0.3	−3.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain (V_{DS} = 15 V, V_{GS} = 0)	I_{DSS}	1.0	5.0	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 kHz)	$\|Y_{fs}\|$	3000	6000	μmhos
Output Admittance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 kHz)	$\|y_{os}\|$	—	50	μmhos
Input Capacitance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	1.0	pF
Output Capacitance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	2.0	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure (V_{DS} = 15 V, I_D = 1.0 mA, YG' = 1.0 mmhos) (R_G = 1.0 kΩ, f = 100 MHz) (V_{DS} = 15 V, V_{GS} = 0, YG' = 1.0 μmho) (R_G = 1.0 MΩ, f = 1.0 kHz)	NF	 — —	 3.0 2.5	dB
Common Source Power Gain (V_{DS} = 15 Vdc, I_D = 1.0 mAdc, f = 100 MHz)	G_{ps}	16	25	dB

MMBF5486

CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)

FET TRANSISTOR

N-CHANNEL

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	25	Vdc
Forward Gate Current	$I_{G(f)}$	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (V_{DS} = 0, I_G = −1.0 μA)	$V_{(BR)GSS}$	−25	—	Vdc
Gate 1 Leakage Current (V_{GS} = −20 V, V_{DS} = 0)	I_{G1SS}	—	−1.0	nA
Gate 2 Leakage Current (V_{GS} = −20 V, V_{DS} = 0, T_A = 100°C)	I_{G2SS}	—	−0.2	μA
Gate Source Cutoff Voltage (V_{DS} = 15 V, I_D = 10 nA)	$V_{GS(off)}$	−2.0	−6.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain (V_{GS} = 0, V_{DS} = 15 V)	I_{DSS}	8.0	20	mA
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{GS} = 0, V_{DS} = 15 V, f = 1.0 kHz)	$\|y_{fs}\|$	4000	8000	μmhos
Input Admittance (V_{GS} = 0, V_{DS} = 15 V, f = 400 MHz)	$Re(y_{is})$	—	1000	μmhos
Output Admittance (V_{GS} = 0, V_{DS} = 15 V, f = 1.0 kHz)	$\|y_{os}\|$	—	75	μmhos
Output Conductance (V_{GS} = 0, V_{DS} = 15 V, f = 400 MHz)	$Re(y_{os})$	—	100	μmhos
Forward Transconductance (V_{GS} = 0, V_{DS} = 15 V, f = 400 MHz)	$Re(y_{fs})$	3500	—	μmhos
Input Capacitance (V_{GS} = 0, V_{DS} = 15 V, f = 1.0 MHz)	C_{iss}	—	5.0	pF
Reverse Transfer Capacitance (V_{GS} = 0, V_{DS} = 15 V, f = 1.0 MHz)	C_{rss}	—	1.0	pF
Output Capacitance (V_{GS} = 0, V_{DS} = 15 V, f = 1.0 MHz)	C_{oss}	—	2.0	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure (V_{DS} = 15 V, I_D = 4.0 mA, f = 100 MHz, Y_G = 1.0 μmhos) (V_{DS} = 15 V, I_D = 4.0 mA, R_G = 1.0 kΩ, f = 400 MHz, Y_G = 1.0 μmhos) (V_{GS} = 0, V_{DS} = 15 V, R_G = 1.0 mΩ, f = 1.0 kHz, Y_G = 1.0 μmhos)	NF	 — — —	 2.0 4.0 2.5	dB
Common Source Power Gain (V_{DS} = 15 V, I_D = 4.0 mA, f = 100 MHz) (V_{DS} = 15 V, I_D = 4.0 mA, f = 400 MHz)	G_{ps}	 18 10	 30 20	dB

MMBFJ310

CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)

FET
VHF/UHF AMPLIFIER
TRANSISTOR

N-CHANNEL

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Gate Current	I_G	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = −1.0 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	−25	—	—	Vdc
Gate Reverse Current (V_{GS} = −15 V) (V_{GS} = −15 V, T_A = 125°C)	I_{GSS}	 — —	 — —	 −1.0 −1.0	 nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 10 Vdc, I_D = 1.0 nAdc)	$V_{GS(off)}$	−2.0	—	−6.5	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain (V_{DS} = 10 Vdc, V_{GS} = 0)	I_{DSS}	24	—	60	mAdc
Gate-Source Forward Voltage (I_G = 1.0 mAdc, V_{DS} = 0)	$V_{GS(f)}$	—	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 10 Vdc, I_D = 10 mAdc, f = 1.0 kHz)	$\|Y_{fs}\|$	8.0	—	18	mmhos
Output Admittance (V_{DS} = 10 Vdc, I_D = 10 mAdc, f = 1.0 kHz)	$\|y_{os}\|$	—	—	200	μmhos
Input Capacitance (V_{GS} = −10 Vdc, V_{DS} = 0 Vdc, f = 1.0 MHz)	C_{iss}	—	—	5.0	pF
Reverse Transfer Capacitance (V_{GS} = −10 Vdc, V_{DS} = 0 Vdc, f = 1.0 MHz)	C_{rss}	—	—	2.5	pF
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 10 Vdc, I_D = 10 mAdc, f = 100 Hz)	$\bar{e}_n$	—	10	—	nV/$\sqrt{Hz}$

MMBFU310

CASE 318-02/03, STYLE 10
SOT-23 (TO-236AA/AB)

FET TRANSISTOR

N-CHANNEL

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Gate Current	I_G	10	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = -1.0\ \mu A$, $V_{DS} = 0$)	$V_{(BR)GSS}$	−25	—	Vdc
Gate 1 Leakage Current ($V_{GS} = -15$ V, $V_{DS} = 0$)	I_{G1SS}	–	−150	pA
Gate 2 Leakage Current ($V_{GS} = -15$ V, $V_{DS} = 0$, $T_A = 125°C$)	I_{G2SS}	—	−150	nA
Gate Source Cutoff Voltage ($V_{DS} = 10$ V, $I_D = 1.0$ nA)	$V_{GS(off)}$	−2.5	−6.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain ($V_{DS} = 10$ V, $V_{GS} = 0$)	I_{DSS}	24	60	mA
Gate-Source Forward Voltage ($I_G = 10$ mA, $V_{DS} = 0$)	$V_{GS(f)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance ($V_{DS} = 10$ V, $I_D = 10$ mA, f = 1.0 kHz)	$\|Y_{fs}\|$	10	18	mmhos
Output Admittance ($V_{DS} = 10$ V, $I_D = 10$ mA, f = 1.0 kHz)	$\|y_{os}\|$	—	150	μmhos
Input Capacitance ($V_{GS} = -10$ V, $V_{DS} = 10$ V, f = 1.0 MHz)	C_{iss}	—	5.0	pF
Reverse Transfer Capacitance ($V_{GS} = -10$ V, $V_{DS} = 10$ V, f = 1.0 MHz)	C_{rss}	—	2.5	pF

MMBPU131

CASE 318-02/03, STYLE 14
SOT-23 (TO-236AA/AB)

UNIJUNCTION TRANSISTOR

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Dissipation Derate Above 25°C	P_D $R_{\theta JA}$	350 2.8	mW mW/°C
DC Gate Current	I_G	±20	mA
Repetitive Peak Forward Current 100 μs Pulse Width, 1.0% Duty Cycle 20 μs Pulse Width, 1.0% Duty Cycle	I_{TRM}	 1.0 1.0	Amp
Non-Repetitive Peak Forward Current 10 μs Pulse Width	I_{TSM}	1.0	Amp
Gate to Cathode Forward Voltage	V_{GKF}	40	Volt
Gate to Cathode Reverse Voltage	V_{GKR}	5.0	Volt
Gate to Anode Reverse Voltage	V_{GAR}	40	Volt
Anode to Cathode Voltage	V_{AK}	±40	Volt

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

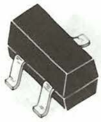
*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Peak-Point Current ($V_S = 10$ Vdc, $R_G = 1.0$ MΩ) ($V_S = 10$ Vdc, $R_G = 10$ kΩ)	I_P	 — —	 2.0 5.0	μA
On-State Voltage ($V_S = 10$ Vdc, $R_G = 1.0$ MΩ)	V_T	0.2	1.6	Volts
Luminous Intensity ($V_S = 10$ Vdc, $R_G = 1.0$ MΩ) ($V_S = 10$ Vdc, $R_G = 10$ kΩ)	I_V	 — 70	 50 —	μA
Anode to Cathode On-State Voltage ($I_F = 50$ mA Peak)	V_F	—	1.5	Volts
Output Voltage ($V_B = 20$ Vdc, $C_C = 0.2$ μF)	V_O	6.0	—	Volts
Rise Time ($V_B = 20$ Vdc, $C_C = 0.2$ μF)	t_r	—	80	ns

MMBR901

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)



3

RF AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	30	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	15	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	25	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	2.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	50	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	30	200	—
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	1.0	pF
Common-Emitter Amplifier Power Gain ($V_{CC} = 6.0$ Vdc, $I_C = 5.0$ mAdc, f = 1.0 GHz)	G_{pe}(1)	16 (Typ)	—	dB
Noise Figure ($I_C = 5.0$ mAdc, $V_{CE} = 6.0$ Vdc, f = 1.0 GHz)	NF(1)	—	1.9 (Typ)	dB

(1) Noise figure and power gain measured on the Ailtech 7380 50Ω system.

MMBR920

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

RF AMPLIFIER/SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	35	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	2.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 10$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 14$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	25	—	250	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 14$ mAdc, $V_{CE} = 10$ Vdc, f = 0.5 GHz)	f_T	—	4.5	—	GHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	—	—	1.0	pF
Noise Figure ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, f = 0.5 GHz) ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 GHz)	NF(1)	 — —	 2.4 3.0	 — —	dB
Common-Emitter Amplifier Power Gain ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, f = 0.5 GHz) ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 GHz)	G_{pe}(1)	 — —	 15 10	 — —	dB

(1) Noise figure and power gain measured on the Ailtech 7380 50 Ω system.

3

MMBR930

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

AMPLIFIER/SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	15	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	35	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	12	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	15	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 5.0 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 30 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	25	—	250	—
SMALL-SIGNAL CHARACTERISTICS					
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	—	1.0	pF
Noise Figure (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 0.5 GHz) (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 GHz)	NF(1)	 — —	 1.9 2.5	 — —	dB
Common-Emitter Amplifier Power Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 0.5 GHz) (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 0.5 GHz)	G_{pe}(1)	 — —	 11 8.0	 — —	dB

(1) Noise figure and power gain measured on the Ailtech 7380 50 Ω system.

MMBR931

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

RF AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	5.0	Vdc
Collector-Base Voltage	V_{CBO}	10	Vdc
Emitter-Base Voltage	V_{EBO}	2.0	Vdc
Collector Current — Continuous	I_C	5.0	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 0.1$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	5.0	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.01$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	10	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	2.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 5.0$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 0.25$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	30	—	150	—
SMALL-SIGNAL CHARACTERISTICS					
Collector-Base Capacitance ($V_{CB} = 1.0$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	—	—	0.5	pF
Noise Figure ($I_E = 0.25$ mAdc, $V_{CE} = 1.0$ Vdc, f = 1.0 GHz)	NF(1)	—	4.3	—	dB
Gate Power Dissipation ($I_E = 0.25$ mAdc, $V_{CE} = 1.0$ Vdc, f = 1.0 GHz)	PG(1)	—	10	—	—

(1) Noise figure and power gain measured on the Ailtech 7380 50 Ω system.

3

MMBR2060

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

RF AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	14	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	14	—	Vdc
Collector Cutoff Current ($V_{CB} = 10$ Vdc, $I_E = 0$)	I_{CBO}	—	50	nAdc
Emitter Cutoff Current ($V_{EB} = 4.0$, $I_C = 0$)	I_{EBO}	—	100	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 20$ mAdc, $V_{CE} = 10$ Vdc, f = 500 MHz)	h_{FE}	 20 2.0	 — —	—
Collector-Emitter Saturation Voltage ($I_C = 80$ mAdc, $I_B = 8.0$ mAdc)	$V_{CE(sat)}$	—	0.38	Vdc
Base-Emitter Saturation Voltage ($I_C = 40$ mAdc, $I_B = 20$ mAdc)	$V_{BE(sat)}$	—	0.98	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 20$ mAdc, $V_{CE} = 1.0$ Vdc, f = 100 MHz)	f_T	—	1.0	GHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$)	C_{cb}	—	1.0	pF
Emitter-Base Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$)	C_{eb}	—	3.0	pF
Noise Figure ($V_{CE} = 10$ Vdc, $I_E = 1.5$ mAdc, f = 450 MHz)	NF(1)	—	3.5	dB
Common-Emitter Amplifier Power Gain ($V_{CE} = 10$ Vdc, $I_E = 1.5$ mAdc, f = 450 Mhz)	G_{pe}(1)	12.5	—	dB

(1) Noise figure and power gain measured on the Ailtech 7380 50 Ω system.

MMBR2857

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

RF TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	2.5	Vdc
Collector Current — Continuous	I_C	40	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 3.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	2.5	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	0.05	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	30	—	—
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	1000	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	C_{cb}	—	1.0	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)	h_{fe}	50	—	—
Noise Figure (I_C = 1.5 mAdc, V_{CE} = 6.0 Vdc, R_S = 50 Ω, f = 450 MHz)	NF	—	4.5	dB
Common-Emitter Amplifier Power Gain (I_C = 1.5 mAdc, V_{CE} = 6.0 Vdc, f = 450 MHz)	G_{PE}	12.5	—	dB

3

MMBR4957

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

RF AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	30	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	30	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 10$ Vdc, $I_C = 0$)	I_{CBO}	—	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	20	150	—
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_E = 2.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	1,200	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	—	0.8	pF
Common-Emitter Amplifier Power Gain(1) ($V_{CE} = 10$ Vdc, $I_C = 2.0$ mAdc, f = 450 MHz)	G_{pe}	17 (Typ)	—	dB
Noise Figure(1) ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, f = 450 MHz)	NF	—	3.0 (Typ)	dB

(1) Noise figure and power gain measured on the Ailtech 7380 50 Ω system.

MMBR5031

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

RF AMPLIFIER TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	10	Vdc
Collector-Base Voltage	V_{CBO}	15	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	20	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	10	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.01$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	15	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.01$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 6.0$ Vdc, $I_E = 0$)	I_{CBO}	—	10	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 6.0$ Vdc)	h_{FE}	25	300	—
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 5.0$ mAdc, $V_{CE} = 6.0$ Vdc, f = 100 MHz)	f_T	1,000	—	MHz
Collector-Base Capacitance ($V_{CE} = 6.0$ Vdc, $I_E = 0$, f = 0.1 MHz)	C_{cb}	—	1.5	pF
Noise Figure ($I_C = 1.0$ mAdc, $V_{CE} = 6.0$ Vdc, f = 450 MHz)	NF(1)	—	2.5	dB
Common-Emitter Amplifier Power Gain ($I_C = 1.0$ mAdc, $V_{CE} = 6.0$ Vdc, f = 450 MHz)	G_{pe}(1)	14	25	dB

(1) Noise figure and power gain measure on Ailtech 7380 50 Ω system.

3

MMBR5179

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

RF AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	2.5	Vdc
Collector Current — Continuous	I_C	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 3.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	12	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.01$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	20	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.01$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	2.5	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	0.02	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 3.0$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	25	—	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	—	1.0	Vdc
SMALL SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 5.0$ mAdc, $V_{CE} = 6.0$ Vdc, f = 100 MHz)	f_T	900	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 0.1 to 1.0 MHz)	C_{cb}	—	1.0	pF
Small Signal Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 6.0$ Vdc, f = 1.0 kHz)	h_{fe}	25	—	—
Noise Figure ($I_C = 1.5$ mAdc, $V_{CE} = 6.0$ Vdc, $R_S = 50\ \Omega$, f = 200 Mhz)	NF(1)	—	4.5	dB
Common-Emitter Amplifier Power Gain ($V_{CE} = 6.0$ Vdc, $I_C = 5.0$ mAdc, f = 200 MHz)	G_{pe}(1)	15	—	dB

(1) Noise figure and power gain measured on the Ailtech 7380 50 Ω system.

MMBS5060,61,62

CASE 318-02/03, STYLE 14
SOT-23 (TO-236AA/AB)

SILICON CONTROLLED RECTIFIER

PNPN DEVICE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Forward Current Avg. (T_C = +67°C)	I_F	510	mA
Peak Forward Gate Voltage	V_{GFM}	5.0	V
Peak Forward Blocking Voltage; RG = 1.0 k MMBS5060 / MMBS5061 / MMBS5062	V_{FXM}	30 / 60 / 100	V

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate Trigger Voltage (R_L = 100 Ω, R_{GC} = 1.0 kΩ, T_C = 125°C) Anode Voltage = MMBS5060 = 30 V, MMBS5061 = 60 V, MMBS5062 = 100 V	V_{GNT}	0.1	—	V
Peak Forward Blocking Current (R_{GC} = 1.0 kΩ, T_C = 125°C) V_{FXM} = MMBS5060 = 30 V, MMBS5061 = 60 V, MMBS5062 = 100 V	I_{FXM}	—	50	μA
Peak Reverse Blocking Current (R_{GC} = 1.0 kΩ, T_C = 125°C) V_{RXM} = MMBS5060 = 30 V, MMBS5061 = 60 V, MMBS5062 = 100 V	I_{RXM}	—	50	μA
Forward Voltage* (I_F = 1.2 A Peak)	V_F	—	1.7	V
Gate Trigger Current** (R_{GC} = 1.0 kΩ, V_{AC} = 7.0 V, R_L = 100 Ω	I_{GT}	—	200	μA
Gate Trigger Voltage (R_{GC} = 1.0 kΩ, V_{AC} = 7.0 V, R_L = 100 Ω	V_{GT}	—	0.8	V
Holding Current (V_{AC} = 7.0 V, R_{GC} = 1.0 kΩ	I_H	—	5.0	mA

*PW ≤ 1.0 ms, D.C. ≤ 1.0%.
**RGC current not included in measurement.

MMBT404,A

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

3

CHOPPER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value 404	Value 404A	Unit
Collector-Emitter Voltage	V_{CEO}	24	35	Vdc
Collector-Base Voltage	V_{CBO}	25	40	Vdc
Emitter-Base Voltage	V_{EBO}	12	25	Vdc
Collector Current — Continuous	I_C	150		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

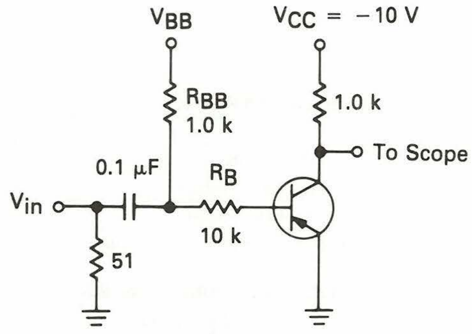
*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)	 MMBT404 MMBT404A	$V_{(BR)CEO}$	 24 35	 — —	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	 MMBT404 MMBT404A	$V_{(BR)CBO}$	 25 40	 — —	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	 MMBT404 MMBT404A	$V_{(BR)EBO}$	 12 25	 — —	 — —	Vdc
Collector Cutoff Current ($V_{CB} = 10$ Vdc, $I_E = 0$)		I_{CBO}	—	—	100	nAdc
Emitter Cutoff Current ($V_{BE} = 10$ Vdc, $I_C = 0$)		I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = 12$ mAdc, $V_{CE} = 0.15$ Vdc)		h_{FE}	30	—	400	—
Collector-Emitter Saturation Voltage ($I_C = 12$ mAdc, $I_B = 0.4$ mAdc) ($I_C = 24$ mAdc, $I_B = 1.0$ mAdc)		$V_{CE(sat)}$	 — —	 — —	 0.15 0.20	Vdc
Base-Emitter Saturation Voltage ($I_C = 12$ mAdc, $I_B = 0.4$ mAdc) ($I_C = 24$ mAdc, $I_B = 1.0$ mAdc)		$V_{BE(sat)}$	 — —	 — —	 0.85 1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Output Capacitance ($V_{CB} = 6.0$ Vdc, $I_E = 0$)		C_{obo}	—	—	20	pF
SWITCHING CHARACTERISTICS						
Delay Time ($V_{CC} = 10$ Vdc, $I_C = 10$ mAdc) (Figure 1)		t_d	—	43	—	ns
Rise Time ($I_{B1} = 1.0$ mAdc, $V_{BE(off)} = 14$ Vdc)		t_r	—	180	—	ns
Storage Time ($V_{CC} = 10$ Vdc, $I_C = 10$ mAdc)		t_s	—	675	—	ns
Fall Time ($I_{B1} = I_{B2} = 1.0$ mAdc) (Figure 1)		t_f	—	160	—	ns

3

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



	V_{in} (Volts)	V_{BB} (Volts)
t_{on}, t_d, t_r	− 12	+1.4
t_{off}, t_s and t_f	+20.6	−11.6

Voltages and resistor values shown are for $I_C = 10$ mA, $I_C/I_B = 10$ and $I_{B1} = I_{B2}$

3

MMBT918

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

VHF/UHF TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	350	mAdc

THERMAL CHARACTERISTICS

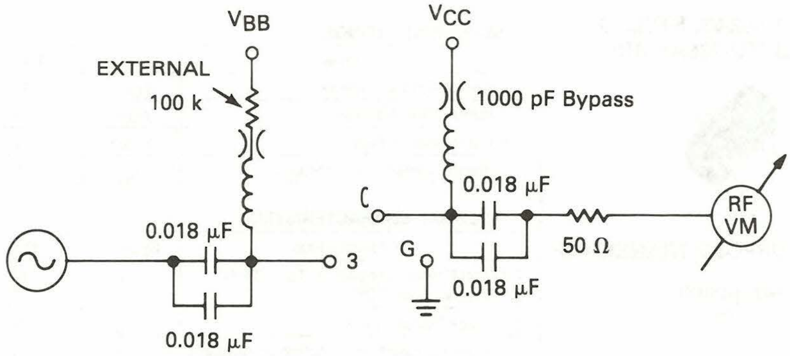
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 3.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	15	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 1.0$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	50	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 3.0$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	20	—	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	600	—	MHz
Output Capacitance ($V_{CB} = 0$ Vdc, $I_E = 0$, f = 1.0 MHz) ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	 — —	 3.0 1.7	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)	C_{ibo}	—	2.0	pF
Noise Figure ($I_C = 1.0$ mAdc, $V_{CE} = 6.0$ Vdc, $R_S = 50\ \Omega$, f = 60 MHz) (Figure 1)	NF	—	6.0	dB
Power Output ($I_C = 8.0$ mAdc, $V_{CB} = 15$ Vdc, f = 500 MHz)	P_{out}	30	—	mW
Common-Emitter Amplifier Power Gain ($I_C = 6.0$ mAdc, $V_{CB} = 12$ Vdc, f = 200 MHz)	G_{pe}	11	—	dB

FIGURE 1 — NF, Gpe MEASUREMENT CIRCUIT 20-200



NF Test Conditions
I_C = 1.0 Amp
V_{CE} = 6.0 Volts
R_S = 50 Ω
f = 60 MHz

Gpe Test Conditions
I_C = 6.0 mA
V_{CE} = 12 Volts
f = 200 MHz

3

MMBT930

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to MPS3904 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CBO}	45	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	30	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	45	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	45	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 5.0 Vdc, I_B = 0)	I_{CEO}	—	10	nAdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)	I_{CBO}	—	10	nAdc
Collector Cutoff Current (V_{CE} = 45 Vdc, V_{BE} = 0)	I_{CES}	—	10	nAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	10	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 μAdc, V_{CE} = 5.0 Vdc) (I_C = 500 μAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	 100 150 —	 300 — 600	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)	$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)	$V_{BE(sat)}$	0.6	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 30 MHz)	f_T	30	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	8.0	pF
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ, f = 10 Hz to 15.7 kHz)	NF	—	3.0	dB

MMBT2222,A

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

TRANSISTOR

NPN SILICON

Refer to MPS2222 for graphs.

3

MAXIMUM RATINGS

Rating	Symbol	MMBT2222	MMBT2222A	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	Vdc
Collector-Base Voltage	V_{CBO}	60	75	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	6.0	Vdc
Collector Current — Continuous	I_C	600		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	 MMBT2222 MMBT2222A	$V_{(BR)CEO}$	 30 40	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	 MMBT2222 MMBT2222A	$V_{(BR)CBO}$	 60 75	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	 MMBT2222 MMBT2222A	$V_{(BR)EBO}$	 5.0 6.0	 — —	Vdc
Collector Cutoff Current (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	 MMBT2222A	I_{CEX}	—	10	nAdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = 125°C) (V_{CB} = 50 Vdc, I_E = 0, T_A = 125°C)	 MMBT2222 MMBT2222A MMBT2222 MMBT2222A	I_{CBO}	 — — — —	 0.01 0.01 10 10	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	 MMBT2222A	I_{EBO}	—	10	nAdc
Base Cutoff Current (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	 MMBT2222A	I_{BL}	—	20	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = −55°C) (I_C = 150 mAdc, V_{CE} = 10 Vdc)(1) (I_C = 150 mAdc, V_{CE} = 1.0 Vdc)(1) (I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	 MMBT2222A only MMBT2222 MMBT2222A	h_{FE}	 35 50 75 35 100 50 30 40	 — — — — 300 — — —	—
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	 MMBT2222 MMBT2222A MMBT2222 MMBT2222A	$V_{CE(sat)}$	 — — — —	 0.4 0.3 1.6 1.0	Vdc

3

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	MMBT2222		—	1.3	
	MMBT2222A		0.6	1.2	
(I_C = 500 mAdc, I_B = 50 mAdc)	MMBT2222		—	2.6	
	MMBT2222A		—	2.0	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2)		f_T			MHz
(I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MMBT2222		250	—	
	MMBT2222A		300	—	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	8.0	pF
Input Capacitance		C_{ibo}			pF
(V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	MMBT2222		—	30	
	MMBT2222A		—	25	
Input Impedance		h_{ie}			kΩ
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		2.0	8.0	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		0.25	1.25	
Voltage Feedback Ratio		h_{re}			$X\ 10^{-4}$
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		—	8.0	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		—	4.0	
Small-Signal Current Gain		h_{fe}			—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		50	300	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		75	375	
Output Admittance		h_{oe}			μmhos
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		5.0	35	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT2222A		25	200	
Collector Base Time Constant (I_E = 20 mAdc, V_{CB} = 20 Vdc, f = 31.8 MHz)	MMBT2222A	$rb'C_c$	—	150	ps
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 kΩ, f = 1.0 kHz)	MMBT2222A	NF	4.0	4.0	dB

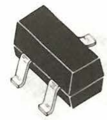
SWITCHING CHARACTERISTICS MMBT2222A only

Characteristic	Conditions	Symbol	Min	Max	Unit
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_d	—	10	ns
Rise Time		t_r	—	25	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_s	—	225	ns
Fall Time		t_f	—	60	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

MMBT2369

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)



SWITCHING TRANSISTOR

NPN SILICON

Refer to MPS2369 for graphs.

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	Vdc
Collector Current — Continuous	I_C	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 125°C)	I_{CBO}	 — —	 — —	 0.4 30	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C) (I_C = 100 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	 40 20 20	 — — —	 120 — —	—
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	—	0.25	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	0.70	—	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	—	4.0	pF
Small Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	h_{fe}	5.0	—	—	—
SWITCHING CHARACTERISTICS					
Storage Time (I_{B1} = I_{B2} = I_C = 10 mAdc)	t_s	—	5.0	13	ns
Turn-On Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc)	t_{on}	—	8.0	12	ns
Turn-Off Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc)	t_{off}	—	10	18	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MMBT2484

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

LOW NOISE TRANSISTOR

NPN SILICON

Refer to MPSA18 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

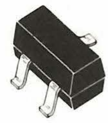
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	60	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 45$ Vdc, $I_E = 0$) ($V_{CB} = 45$ Vdc, $I_E = 0$, T_A 150°C)	I_{CBO}	 — —	 10 10	 nAdc μAdc
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$)	I_{EBO}	—	10	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	 250 —	 — 800	—
Collector-Emitter Saturation Voltage ($I_C = 1.0$ mAdc, $I_B = 0.1$ mAdc)	$V_{CE(sat)}$	—	0.35	Vdc
Base-Emitter On Voltage ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)	$V_{BE(on)}$	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 140 kHz)	C_{obo}	—	6.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 140 kHz)	C_{ibo}	—	6.0	pF
Noise Figure ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ kΩ, f = 1.0 kHz, BW = 200 Hz)	NF	—	3.0	dB

3

MMBT2907,A

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)



GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to MPS2907 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPS2907	MPS2907A	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	 MMBT2907 MMBT2907A	$V_{(BR)CEO}$	 40 60	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)		$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 30$ Vdc, $V_{BE(off)} = 0.5$ Vdc)		I_{CEX}	—	50	nAdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$) ($V_{CB} = 50$ Vdc, $I_E = 0$, $T_A = 125°C$)	 MMBT2907 MMBT2907A MMBT2907 MMBT2907A	I_{CBO}	 — — — —	 0.020 0.010 20 10	μAdc
Base Current ($V_{CE} = 30$ Vdc, $V_{BE(off)} = 0.5$ Vdc)		I_B	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)(1) ($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc)(1)	 MMBT2907 MMBT2907A MMBT2907 MMBT2907A MMBT2907 MMBT2907A MMBT2907, MMBT2907A MMBT2907 MMBT2907A	h_{FE}	 35 75 50 100 75 100 100 30 50	 — — — — — — 300 — —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)		$V_{CE(sat)}$	 — —	 0.4 1.6	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)		$V_{BE(sat)}$	 — —	 1.3 2.6	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1),(2) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	30	pF
SWITCHING CHARACTERISTICS					
Turn-On Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_{on}	—	45	ns
Delay Time		t_d	—	10	ns
Rise Time		t_r	—	40	ns
Turn-Off Time	(V_{CC} = 6.0 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_{off}	—	100	ns
Storage Time		t_s	—	80	ns
Fall Time		t_f	—	30	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

MMBT3640

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

SWITCHING TRANSISTOR

PNP SILICON

3

Refer to MPS3640 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	12	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	80	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	12	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{CEO(sus)}$	12	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	12	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CE} = 6.0 Vdc, V_{BE} = 0) (V_{CE} = 6.0 Vdc, V_{BE} = 0, T_A = 65°C)	I_{CES}	— —	0.01 1.0	μAdc
Base Current (V_{CE} = 6.0 Vdc, V_{BE} = 0)	I_B	—	10	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 0.3 Vdc) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	30 20	120 —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = 65°C)	$V_{CE(sat)}$	— — —	0.2 0.6 0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	0.75 0.8 —	0.95 1.0 1.5	Vdc
SMALL SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	500	—	MHz
Output Capacitance (V_{CB} = = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	3.5	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	3.5	pF
SWITCHING CHARACTERISTICS				
Delay Time (V_{CC} = 6.0 Vdc, I_C = 50 mAdc, $V_{BE(off)}$ = 1.9 Vdc, I_{B1} = 5.0 mAdc)	t_d	—	10	ns
Rise Time	t_r	—	30	ns
Storage Time (V_{CC} = 6.0 Vdc, I_C = 50 mAdc, I_{B1} = I_{B2} = 5.0 mAdc)	t_s	—	20	ns
Fall Time	t_f	—	12	ns
Turn-On Time (V_{CC} = 6.0 Vdc, I_C = 50 mAdc, $V_{BE(off)}$ = 1.9 Vdc, I_{B1} = 5.0 mAdc) (V_{CC} = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 0.5 mAdc)	t_{on}	 — —	 25 60	ns
Turn-Off Time (V_{CC} = 6.0 Vdc, I_C = 50 mAdc, $V_{BE(off)}$ = 1.9 V, I_{B1} = I_{B2} = 5.0 mAdc) (V_{CC} = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 0.5 mAdc)	t_{off}	 — —	 35 75	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MMBT3903
MMBT3904

CASE 318-03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N3903 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltge	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)		$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	6.0	—	Vdc
Base Cutoff Current ($V_{CE} = 30$ Vdc, $V_{EB} = 3.0$ Vdc)		I_{BL}	—	50	nAdc
Collector Cutoff Current ($V_{CE} = 30$ Vdc, $V_{EB} = 3.0$ Vdc)		I_{CEX}	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain(1)		h_{FE}			—
($I_C = 0.1$ mAdc, $V_{CE} = 1.0$ Vdc)	MMBT3903 MMBT3904		20 40	— —	
($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc)	MMBT3903 MMBT3904		35 70	— —	
($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)	MMBT3903 MMBT3904		50 100	150 300	
($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc)	MMBT3903 MMBT3904		30 60	— —	
($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)	MMBT3903 MMBT3904		15 30	— —	
Collector-Emitter Saturation Voltage(1) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{CE(sat)}$	 — —	 0.2 0.3	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{BE(sat)}$	 0.65 —	 0.85 0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	MMBT3903 MMBT3904	f_T	250 300	— —	MHz

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	8.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT3903	h_{ie}	1.0	8.0	k ohms
	MMBT3904		1.0	10	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT3903	h_{re}	0.1	5.0	X 10^{-4}
	MMBT3904		0.5	8.0	
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMBT3903	h_{fe}	50	200	—
	MMBT3904		100	400	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	1.0	40	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohms, f = 10 Hz to 15.7 kHz)	MMBT3903	NF	—	6.0	dB
	MMBT3904		—	5.0	

SWITCHING CHARACTERISTICS

			Symbol	Min	Max	Unit
Delay Time	(V_{CC} = 3.0 Vdc, V_{BE} = 0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)		t_d	—	35	ns
Rise Time			t_r	—	35	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	MMBT3903	t_s	—	175	ns
		MMBT3904		—	200	
Fall Time			t_f	—	50	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

3

MMBT3906

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to 2N3905 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Base Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 3.0 Vdc)	I_{BL}	—	50	nAdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 3.0 Vdc)	I_{CEX}	—	50	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 60 80 100 60 30	 — — 300 — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	 — —	 0.25 0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	 0.65 —	 0.85 0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	250	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	4.5	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	10.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	2.0	12	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{re}	0.1	10	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	100	400	—

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	3.0	60	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohm, f = 10 10 Hz to 15.7 kHz)		NF	—	4.0	dB
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 3.0 Vdc, V_{BE} = 0.5 Vdc I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_d	—	35	ns
Rise Time		t_r	—	35	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	t_s	—	225	ns
Fall Time		t_f	—	75	ns

(1) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

3

3

MMBT4124

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N4123 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N4124	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_E = 0)	$V_{(BR)CEO}$	25	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	50	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	50	nAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 2.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 120 60	 360 —	—
Collector-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	—	0.3	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	300	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	8.0	pF
Collector-Base Capacitance (I_E = 0, V_{CB} = 5.0 V, f = 100 kHz)	C_{cb}	—	4.0	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	120	480	—
Current Gain — High Frequency (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz) (I_C = 2.0 mAdc, V_{CE} = 10 V, f = 1.0 kHz)	$\|h_{fe}\|$	 3.0 120	 — 480	—
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kohm, Noise Bandwidth = 10 Hz to 15.7 kHz)	NF	—	5.0	dB

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

MAXIMUM RATINGS

Rating	Symbol	2N4125	2N4126	Unit
Collector-Emitter Voltage	V_{CEO}	30	25	Vdc
Collector-Base Voltage	V_{CBO}	30	25	Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	350 2.8		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

MMBT4125

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

3

Refer to 2N4125 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_E = 0$)	$V_{(BR)CEO}$	30	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)	I_{CBO}	—	50	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	50	nAdc
ON CHARACTERISTICS				
DC Current Gain(1) ($I_C = 2.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	 50 25	 150 —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{BE(sat)}$	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	200	—	MHz
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)	C_{ibo}	—	10	pF
Collector-Base Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 100 kHz)	C_{cb}	—	4.5	pF
Small-Signal Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{fe}	50	200	—
Current Gain — High Frequency ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	$\|h_{fe}\|$	2.0	—	—
Noise Figure ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc, $R_S = 1.0$ kohm, Noise Bandwidth = 10 Hz to 15.7 kHz)	NF	—	5.0	dB

(1) Pulse Test: Pulse Width = 300 μsec, Duty Cycle = 2.0%.

MMBT4401

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	600	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

Refer to 2N4401 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	Vdc
Base Cutoff Current (V_{CE} = 35 Vdc, V_{EB} = 0.4 Vdc)	I_{BEV}	—	0.1	μAdc
Collector Cutoff Current (V_{CE} = 35 Vdc, V_{EB} = 0.4 Vdc)	I_{CEX}	—	0.1	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 150 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	20 40 80 100 40	— — — 300 —	—
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	— —	0.4 0.75	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	0.75 —	0.95 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	250	—	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	—	6.5	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{eb}	—	30	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	1.0	15	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{re}	0.1	8.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	40	500	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	1.0	30	μmhos

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
Delay Time	(V_{CC} = 30 Vdc, V_{EB} = 2.0 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_d	—	15	ns
Rise Time		t_r	—	20	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_s	—	225	ns
Fall Time		t_f	—	30	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MMBT4403

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

SWITCHING TRANSISTOR

PNP SILICON

3

Refer to 2N4402 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	600	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)		$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Base Cutoff Current (V_{CE} = 35 Vdc, V_{BE} = 0.4 Vdc)		I_{BEV}	—	0.1	μAdc
Collector Cutoff Current (V_{CE} = 35 Vdc, V_{BE} = 0.4 Vdc)		I_{CEX}	—	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 150 mAdc, V_{CE} = 2.0 Vdc)(1) (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)(1)		h_{FE}	30 60 100 100 20	— — — 300 —	—
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{CE(sat)}$	— —	0.4 0.75	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{BE(sat)}$	0.75 —	0.95 1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	200	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)		C_{cb}	—	8.5	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)		C_{eb}	—	30	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{ie}	1.5k	15k	ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{re}	0.1	8.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	60	500	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	1.0	100	μmhos
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 30 Vdc, V_{BE} = 2.0 Vdc,	t_d	—	15	ns
Rise Time	I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_r	—	20	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc,	t_s	—	225	ns
Fall Time	I_{B1} = I_{B2} = 15 mAdc)	t_f	—	30	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

3

MMBT5086,87

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

LOW NOISE TRANSISTOR

PNP SILICON

Refer to 2N5086 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CBO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	50	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		$V_{(BR)CBO}$	50	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0) (V_{CB} = 35 Vdc, I_E = 0)		I_{CBO}	 — —	 10 50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	 MMBT5086 MMBT5087	h_{FE}	 150 250	 500 800	—
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MMBT5086 MMBT5087		150 250	— —	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MMBT5086 MMBT5087		150 250	— —	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	—	0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	—	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	40	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	4.0	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	 MMBT5086 MMBT5087	h_{fe}	 150 250	 600 900	—
Noise Figure (I_C = 20 mAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ, f = 10 Hz to 15.7 kHz)	 MMBT5086 MMBT5087	NF	 — —	 3.0 2.0	dB
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 3.0 kΩ, f = 1.0 kHz)	 MMBT5086 MMBT5087		 — —	 3.0 2.0	

MMBT5088,89

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

LOW NOISE TRANSISTOR

NPN SILICON

Refer to MPSA18 for graphs.

3

MAXIMUM RATINGS

Rating	Symbol	Value MMBT5088	Value MMBT5089	Unit
Collector-Emitter Voltage	V_{CEO}	30	25	Vdc
Collector-Base Voltage	V_{CBO}	35	30	Vdc
Emitter-Base Voltage	V_{EBO}	4.5		Vdc
Collector Current — Continuous	I_C	50		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	MMBT5088 MMBT5089	$V_{(BR)CEO}$	30 25	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MMBT5088 MMBT5089	$V_{(BR)CBO}$	35 30	— —	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0)	MMBT5088 MMBT5089	I_{CBO}	— —	50 50	nAdc
Emitter Cutoff Current ($V_{EB(off)}$ = 3.0 Vdc, I_C = 0) ($V_{EB(off)}$ = 4.5 Vdc, I_C = 0)	MMBT5088 MMBT5089	I_{EBO}	— —	50 100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	MMBT5088 MMBT5089	h_{FE}	300 400	900 1200	—
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MMBT5088 MMBT5089		350 450	— —	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MMBT5088 MMBT5089		300 400	— —	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	—	0.8	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	50	—	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz emitter guarded)		C_{cb}	—	4.0	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz collector guarded)		C_{eb}	—	10	pF
Small Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	MMBT5088 MMBT5089	h_{fe}	350 450	1400 1800	—
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ, f = 10 Hz to 15.7 Hz)	MMBT5088 MMBT5089	NF	— —	3.0 2.0	dB

3

MMBT5401

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

HIGH VOLTAGE TRANSISTOR

PNP SILICON

Refer to 2N5401 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	150	Vdc
Collector-Base Voltage	V_{CBO}	160	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	150	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	160	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 100 Vdc, I_E = 0) (V_{CB} = 100 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 — —	 50 50	 nAdc μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	 50 60 50	 — 240 —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	 — —	 0.20 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	 — —	 1.0 1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	100	300	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	6.0	pF
Small Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	40	200	—
Noise Figure (I_C = 200 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 ohms, f = 10 Hz to 15.7 kHz)	NF	—	8.0	dB

MMBT5550

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

HIGH VOLTAGE TRANSISTOR

NPN SILICON

Refer to 2N5550 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	140	Vdc
Collector-Base Voltage	V_{CBO}	160	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	600	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	140	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_C = 0$)	$V_{(BR)CBO}$	160	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 100$ Vdc, $I_E = 0$) ($V_{CB} = 100$ Vdc, $I_E = 0$, $T_A = 100°C$)	I_{CBO}	 — —	 100 100	 nAdc μAdc
Emitter Cutoff Current ($V_{EB} = 4.0$ Vdc, $I_C = 0$)	I_{EBO}	—	50	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	 60 60 20	 — 250 —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{CE(sat)}$	 — —	 0.15 0.25	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{BE(sat)}$	 — —	 1.0 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	100	300	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	6.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)	C_{ibo}	—	30	pF

MMBT6427

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

DARLINGTON TRANSISTOR

NPN SILICON

Refer to 2N6426 for graphs.

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	12	Vdc
Collector Current — Continuous	I_C	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	12	—	Vdc
Collector Cutoff Current ($V_{CE} = 25$ Vdc, $I_B = 0$)	I_{CEO}	—	1.0	μAdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	50	nAdc
Emitter Cutoff Current ($V_{BE} = 10$ Vdc, $I_C = 0$)	I_{EBO}	—	50	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 500$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	 10,000 20,000 14,000	 100,000 200,000 140,000	—
Collector-Emitter Saturation Voltage ($I_C = 50$ mAdc, $I_B = 0.5$ mAdc) ($I_C = 500$ mAdc, $I_B = 0.5$ mAdc)	$V_{CE(sat)}$	 — —	 1.2 1.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 500$ mAdc, $I_B = 0.5$ mAdc)	$V_{BE(sat)}$	—	2.0	Vdc
Base-Emitter On Voltage ($I_C = 50$ mAdc, $V_{CE} = 5.0$ Vdc)	$V_{BE(on)}$	—	1.75	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	7.0	pF
Input Capacitance ($V_{BE} = 0.5$, $I_C = 0$, f = 1.0 MHz)	C_{ibo}	—	15	pF
Current Gain — High Frequency ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)	$\|h_{fe}\|$	1.3	—	Vdc
Noise Figure ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, $R_S = 100$ kΩ, f = 1.0 kHz to 15.7 kHz)	NF	—	10	dB

MMBT6428,29

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MPSA18 for graphs.

3

MAXIMUM RATINGS

Rating	Symbol	Value MMBT6428	Value MMBT6429	Unit
Collector-Emitter Voltage	V_{CEO}	50	45	Vdc
Collector-Base Voltage	V_{CBO}	60	55	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	200		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage		$V_{(BR)CEO}$			Vdc
(I_C = 1.0 mAdc, I_B = 0)	MMBT6428		50	—	
(I_C = 1.0 mAdc, I_B = 0)	MMBT6429		45	—	
Collector-Base Breakdown Voltage		$V_{(BR)CBO}$			Vdc
(I_C = 0.1 mAdc, I_E = 0)	MMBT6428		60	—	
(I_C = 0.1 mAdc, I_E = 0)	MMBT6429		55	—	
Collector Cutoff Current (V_{CE} = 30 Vdc)		I_{CEO}	—	0.1	μAdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	—	0.01	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	—	0.01	μAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 0.01 mAdc, V_{CE} = 5.0 Vdc)	MMBT6428		250	—	
	MMBT6429		500	—	
(I_C = 0.1 mAdc, V_{CE} = 5.0 Vdc)	MMBT6428		250	650	
	MMBT6429		500	1250	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MMBT6428		250	—	
	MMBT6429		500	—	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MMBT6428		250	—	
	MMBT6429		500	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 0.5 mAdc)			—	0.2	
(I_C = 100 mAdc, I_B = 5.0 mAdc)			—	0.6	
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	0.56	0.66	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	100	700	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	3.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	8.0	pF

3

MMBT6517

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

HIGH VOLTAGE TRANSISTOR

NPN SILICON

Refer to 2N6517 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	350	Vdc
Collector-Base Voltage	V_{CBO}	350	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Base Current	I_B	250	mA
Collector Current — Continuous	I_C	500	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mA)	$V_{(BR)CEO}$	350	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu A$)	$V_{(BR)CBO}$	350	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu A$)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 250$ V)	I_{CBO}	—	50	nA
Emitter Cutoff Current ($V_{EB} = 5.0$ V)	I_{EBO}	—	50	nA
ON CHARACTERISTICS				
DC Current Gain ($I_C = 1.0$ mA, $V_{CE} = 10$ V) ($I_C = 10$ mA, $V_{CE} = 10$ V) ($I_C = 30$ mA, $V_{CE} = 10$ V) ($I_C = 50$ mA, $V_{CE} = 10$ V) ($I_C = 100$ mA, $V_{CE} = 10$ V)	h_{FE}	 20 30 30 20 15	 — — 200 100 —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mA, $I_B = 1.0$ mA) ($I_C = 20$ mA, $I_B = 2.0$ mA) ($I_C = 30$ mA, $I_B = 3.0$ mA) ($I_C = 50$ mA, $I_B = 5.0$ mA)	$V_{CE(sat)}$	 — — — —	 0.30 0.35 0.50 1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mA, $I_B = 1.0$ mA) ($I_C = 20$ mA, $I_B = 2.0$ mA) ($I_C = 30$ mA, $I_B = 3.0$ mA)	$V_{BE(sat)}$	 — — —	 0.75 0.85 0.90	Vdc
Base-Emitter On Voltage ($I_C = 100$ mA, $V_{CE} = 10$ V)	$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mA, $V_{CE} = 20$ V, f = 20 MHz)	f_T	40	200	MHz
Collector-Base Capacitance ($V_{CB} = 20$ V, f = 1.0 MHz)	C_{cb}	—	6.0	pF
Emitter-Base Capacitance ($V_{EB} = 0.5$ V, f = 1.0 MHz)	C_{eb}	—	80	pF

MMBT6520

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

HIGH VOLTAGE TRANSISTOR

PNP SILICON

Refer to 2N6520 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	350	Vdc
Collector-Base Voltage	V_{CBO}	350	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Base Current	I_B	250	mA
Collector Current — Continuous	I_C	500	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mA)	$V_{(BR)CEO}$	350	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CBO}$	350	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μA)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 250 V)	I_{CBO}	—	50	nA
Emitter Cutoff Current (V_{EB} = 4.0 V)	I_{EBO}	—	50	nA
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 mA, V_{CE} = 10 V) (I_C = 10 mA, V_{CE} = 10 V) (I_C = 30 mA, V_{CE} = 10 V) (I_C = 50 mA, V_{CE} = 10 V) (I_C = 100 mA, V_{CE} = 10 V)	h_{FE}	 20 30 30 20 15	 — — 200 100 —	—
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_B = 1.0 mA) (I_C = 20 mA, I_B = 2.0 mA) (I_C = 30 mA, I_B = 3.0 mA) (I_C = 50 mA, I_B = 5.0 mA)	$V_{CE(sat)}$	 — — — —	 0.30 0.35 0.50 1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mA, I_B = 1.0 mA) (I_C = 20 mA, I_B = 2.0 mA) (I_C = 30 mA, I_B = 3.0 mA)	$V_{BE(sat)}$	 — — —	 0.75 0.85 0.90	Vdc
Base-Emitter On Voltage (I_C = 100 mA, V_{CE} = 10 V)	$V_{BE(on)}$			Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mA, V_{CE} = 20 V, f = 20 MHz)	f_T	40	200	MHz
Collector-Base Capacitance (V_{CB} = 20 V, f = 1.0 MHz)	C_{cb}	—	6.0	pF
Emitter-Base Capacitance (V_{EB} = 0.5 V, f = 1.0 MHz)	C_{eb}	—	100	pF

MMBT6543

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MPS6543 for graphs.

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	35	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	25	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	35	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 25$ Vdc, $I_E = 0$)	I_{CBO}	—	—	0.1	μAdc
Emitter Cutoff Current ($V_{BE} = 2.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain(2) ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	25	60	—	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	200	350	mVdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	—	750	950	mVdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 4.0$ mAdc, $V_{CE} = 12$ Vdc, f = 100 MHz)	f_T	750	1100	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	0.8	1.0	pF
Collector Base Time Constant ($I_E = 4.0$ mAdc, $V_{CE} = 12$ Vdc, f = 31.8 MHz)	$rb'C_c$	—	—	9.5	ps

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MMBTA05,06

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

DRIVER TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value MMBTA05	Value MMBTA06	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	500		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	 MMBTA05 MMBTA06	$V_{(BR)CEO}$	 60 80	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 60$ Vdc, $I_B = 0$)		I_{CEO}	—	0.1	μAdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 80$ Vdc, $I_E = 0$)	 MMBTA05 MMBTA06	I_{CBO}	 — —	 0.1 0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)		h_{FE}	 50 50	 — —	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 10$ mAdc)		$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter On Voltage ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)		$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 10$ mA, $V_{CE} = 2.0$ V, f = 100 MHz)		f_T	100	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

3

MMBTA13,14

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

DARLINGTON AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N6426 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	10	Vdc
Collector Current — Continuous	I_C	300	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu Adc$, $I_B = 0$)		$V_{(BR)CES}$	30	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{BE} = 10$ Vdc, $I_C = 0$)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)	 MMBTA13 MMBTA14 MMBTA13 MMBTA14	h_{FE}	 5000 10,000 10,000 20,000	 — — — —	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 0.1$ mAdc)		$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)		V_{BE}	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)		f_T	125	—	MHz

(1) Pulse Test: Pulse Width $\leq 300\ \mu s$, Duty Cycle $\leq 2.0\%$.
(2) $f_T = |h_{fe}| \cdot f_{test}$.

MMBTA20

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE AMPLIFIER

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

Refer to MPS3904 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	40	400	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	125	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	4.0	pF

MMBTA42,43

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

HIGH VOLTAGE TRANSISTOR

NPN SILICON

Refer to MPSA42 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value MMBTA42	Value MMBTA43	Unit
Collector-Emitter Voltage	V_{CEO}	300	200	Vdc
Collector-Base Voltage	V_{CBO}	300	200	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	6.0	Vdc
Collector Current — Continuous	I_C	500		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	 MMBTA42 MMBTA43	$V_{(BR)CEO}$	 300 200	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	 MMBTA42 MMBTA43	$V_{(BR)CBO}$	 300 200	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 200$ Vdc, $I_E = 0$) ($V_{CB} = 160$ Vdc, $I_E = 0$)	 MMBTA42 MMBTA43	I_{CBO}	 — —	 0.1 0.1	μAdc
Emitter Cutoff Current ($V_{BE} = 6.0$ Vdc, $I_C = 0$) ($V_{BE} = 4.0$ Vdc, $I_C = 0$)	 MMBTA42 MMBTA43	I_{EBO}	 — —	 0.1 0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)	 Both Types Both Types MMBTA42 MMBTA43	h_{FE}	 25 40 40 40	 — — —	—
Collector-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)	 MMBTA42 MMBTA43	$V_{CE(sat)}$	 — —	 0.5 0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)		f_T	50	—	MHz
Collector-Base Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 1.0 MHz)	 MMBTA42 MMBTA43	C_{cb}	 — —	 3.0 4.0	pF

(1) Pulse Test: Pulse Width $\leq 300\ \mu s$, Duty Cycle $\leq 2.0\%$.

MMBTA55,56

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

DRIVER TRANSISTOR

PNP SILICON

3

MAXIMUM RATINGS

Rating	Symbol	MMBTA55	MMBTA56	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	500		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	 MMBTA55 MMBTA56	$V_{(BR)CEO}$	 60 80	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 60$ Vdc, $I_B = 0$)		I_{CEO}	—	0.1	μAdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 80$ Vdc, $I_E = 0$)	 MMBTA55 MMBTA56	I_{CBO}	 — —	 0.1 0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)		h_{FE}	 50 50	 — —	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 10$ mAdc)		$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter On Voltage ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)		$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc, f = 100 MHz)		f_T	50	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

3

MMBTA63
MMBTA64

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

DARLINGTON TRANSISTOR

PNP SILICON

Refer to MPSA75 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	10	Vdc
Collector Current — Continuous	I_C	500	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu Adc$)		$V_{(BR)CES}$	30	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{BE} = 10$ Vdc)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain(1)		h_{FE}			—
($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	MMBTA63		5,000	—	
($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	MMBTA64		10,000	—	
($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)	MMBTA63		10,000	—	
($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)	MMBTA64		20,000	—	
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 0.1$ mAdc)		$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)		$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 50$ Vdc, f = 100 MHz)		f_T	125	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MMBTA70

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to 2N5086 for graphs.

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	40	400	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	125	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	4.0	pF

MMBTA92,93

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

HIGH VOLTAGE TRANSISTOR

PNP SILICON

Refer to MPSA92 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MMBTA92	MMBTA93	Unit
Collector-Emitter Voltage	V_{CEO}	300	200	Vdc
Collector-Base Voltage	V_{CBO}	300	200	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	5.0	Vdc
Collector Current — Continuous	I_C	500		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	 MMBTA92 MMBTA93	$V_{(BR)CEO}$	 300 200	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 MMBTA92 MMBTA93	$V_{(BR)CBO}$	 300 200	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0) (V_{CB} = 160 Vdc, I_E = 0)	 MMBTA92 MMBTA93	I_{CBO}	 — —	 0.25 0.25	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	 Both Types Both Types MMBTA92 MMBTA93	h_{FE}	 25 40 25 25	 — — — —	—
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	 MMBTA92 MMBTA93	$V_{CE(sat)}$	 — —	 0.5 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	50	—	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	 MMBTA92 MMBTA93	C_{cb}	 — —	 6.0 8.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MMBTH10

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

VHF/UHF TRANSISTOR

NPN SILICON

Refer to MPSH10 for graphs.

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	25	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 25$ Vdc, $I_E = 0$)	I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{BE} = 2.0$ Vdc, $I_C = 0$)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	60	—	—
Collector-Emitter Saturation Voltage ($I_C = 4.0$ mAdc, $I_B = 0.4$ mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc)	V_{BE}	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	650	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	—	0.7	pF
Common-Base Feedback Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{rb}	0.35	0.65	pF
Collector Base Time Constant ($I_C = 4.0$ mAdc, $V_{CB} = 10$ Vdc, f = 31.8 MHz)	$r_b'C_c$	—	9.0	ps

3

MMBTH24

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

VHF MIXER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 8.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30	—	—	—
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) (I_C = 8.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	620	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	0.25	0.36	pF
Conversion Gain (213 MHz to 45 MHz) (I_C = 8.0 mAdc, V_{CC} = 20 Vdc, Oscillator Injection = 150 mVrms) (60 MHz to 45 MHz) (I_C = 8.0 mAdc, V_{CC} = 20 Vdc, Oscillator Injection = 150 mVrms)	— C_G	 19 24	 24 29	 — —	dB

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MMBTH81

CASE 318-02/03, STYLE 6
SOT-23 (TO-236AA/AB)

UHF/VHF TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 10$ Vdc, $I_E = 0$)	I_{CBO}	—	—	100	nAdc
Emitter Cutoff Current ($V_{BE} = 2.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	60	—	—	—
Collector-Emitter Saturation Voltage ($I_C = 5.0$ mAdc, $I_B = 0.5$ mAdc)	$V_{CE(sat)}$	—	—	0.5	Vdc
Base-Emitter On Voltage ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc)	$V_{BE(on)}$	—	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	600	—	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	—	—	0.85	pF
Collector-Emitter Capacitance ($I_B = 0$, $V_{CB} = 10$ Vdc, f = 1.0 MHz)	C_{ce}	—	—	0.65	pF

3

MMBV105G

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)

VOLTAGE VARIABLE CAPACITANCE DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Vdc
Forward Current	I_F	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Reverse Breakdown Voltage ($I_R = 10\ \mu Adc$)	$V_{(BR)}$	30	—	—	Vdc
Reverse Voltage Leakage Current ($V_R = 28$ Vdc)	I_R	—	—	50	nAdc
Series Inductance (f = 250 MHz)	L_S	—	3.0	—	nH
Diode Capacitance Temperature Coefficient ($V_R = 3.0$ Vdc, f = 1.0 MHz)	TC_C	—	280	—	ppm/°C
Diode Capacitance ($V_R = 25$ Vdc)	C_T	1.8	—	2.8	pF
Capacitance Ratio ($V_{R1} = 3.0$ Vdc, $V_{R2} = 25$ Vdc, f = 1.0 MHz)	C3/C25	4.0	—	6.0	—

MMBV109

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)

VOLTAGE VARIABLE CAPACITANCE DIODE

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Vdc
Forward Current	I_F	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Reverse Breakdown Voltage ($I_R = 10\ \mu Adc$)	$V_{(BR)}$	30	—	—	Vdc
Reverse Voltage Leakage Current ($V_R = 28$ Vdc)	I_R	—	—	0.1	μAdc
Series Inductance (f = 250 MHz)	L_S	—	3.0	—	nH
Case Capacitance (f = 1.0 MHz)	C_C	—	0.1	—	pF
Diode Capacitance Temperature Coefficient ($V_R = 3.0$ Vdc, f = 1.0 MHz)	T_{CC}	—	280	—	ppm/°C
Figure of Merit ($V_R = 3.0$ Vdc, f = 50 MHz)	Q	280	—	—	—
Diode Capacitance ($V_R = 3.0$ Vdc, f = 1.0 MHz)	C_T	26	—	32	pF

MMBV2101 thru MMBV2109

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)

TUNING DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Vdc
Forward Current	I_F	20	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Reverse Breakdown Voltage ($I_R = 10\ \mu Adc$)	$V_{(BR)}$	30	—	—	Vdc
Reverse Voltage Leakage Current ($V_R = 25$ Vdc)	I_R	—	—	20	nAdc
Series Inductance (f = 250 MHz, Lead Length ≈ 1/16″)	L_S	—	3.0	—	nH
Case Capacitance (f = 1.0 MHz, Lead Length ≈ 1/16″)	C_C	—	0.15	—	pF
Diode Capacitance Temperature Coefficient ($V_R = 4.0$ Vdc, f = 1.0 MHz)	T_{CC}	—	280	400	ppm/°C

Device	C_T, Diode Capacitance $V_R = 4.0$ Vdc, f = 1.0 MHz pF			Q, Figure of Merit $V_R = 4.0$ Vdc f = 50 MHz	TR, Tuning Ratio C_2/C_{30} f = 1.0 MHz		Marking
	Min	Nom	Max	Min	Min	Max	Top
MMBV-2101	6.1	6.8	7.5	400	2.5	3.3	4G
MMBV-2102	7.3	8.2	9.0	400	2.6	3.3	4S
MMBV-2103	9.0	10	11	350	2.6	3.3	4H
MMBV2104	10.8	12	13.2	350	2.6	3.3	4T
MMBV-2105	13.5	15	16.5	350	2.6	3.3	4U
MMBV-2106	16.2	18	19.8	300	2.7	3.3	4V
MMBV-2107	19.8	22	24.2	300	2.7	3.3	4W
MMBV-2108	24.3	27	29.7	250	2.7	3.3	4X
MMBV-2109	29.7	33	36.3	150	2.7	3.3	4J

MMBV3102

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)

VOLTAGE VARIABLE CAPACITANCE DIODE

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Vdc
Forward Current	I_F	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Reverse Breakdown Voltage ($I_R = 10\ \mu Adc$)	$V_{(BR)}$	30	—	—	Vdc
Reverse Voltage Leakage Current ($V_R = 25$ Vdc)	I_R	—	—	0.1	μAdc
Series Inductance (f = 250 MHz)	L_S	—	3.0	—	nH
Case Capacitance (f = 1.0 MHz)	C_C	—	0.1	—	pF
Diode Capacitance Temperature Coefficient ($V_R = 3.0$ Vdc, f = 1.0 MHz)	T_{CC}	—	280	—	ppm/°C
Figure of Merit ($V_R = 3.0$ Vdc, f = 50 MHz)	Q	300	—	—	—
Diode Capacitance ($V_R = 3.0$ Vdc, f = 1.0 MHz)	C_T	20	—	25	pF

3

MMBV3401

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)

SILICON PIN SWITCHING DIODE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	35	Vdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Reverse Breakdown Voltage ($I_R = 10\ \mu Adc$)	$V_{(BR)}$	35	—	—	Vdc
Reverse Voltage Leakage Current ($V_R = 25$ Vdc)	I_R	—	—	0.1	μAdc
Series Inductance (f = 250 MHz)	L_S	—	3.0	—	nH
Series Resistance ($I_F = 10$ mAdc)	R_S	—	—	0.7	Ohms
Case Capacitance (f = 1.0 MHz)	C_C	—	0.1	—	pF
Diode Capacitance ($V_R = 20$ Vdc, f = 1.0 MHz)	C_T	—	—	1.0	pF

MMBZ5226 thru MMBZ5257

CASE 318-02/03, STYLE 8
SOT-23 (TO-236AA/AB)

ZENER DIODES

3

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	357	°C/W

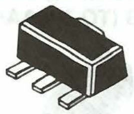
*Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

V_F = 0.9 V Max @ I_F = 10 mA for all types.

MMBZ	Marking	Test Current I_{ZT} mA	Zener Voltage V_Z Min	Nominal	Max	Max Zener Impedance @ I_{ZT} Ω	Max I_R μA	@ V_R V
5226	8A	5.0	3.1	3.3	3.5	175	25	.95
5227	8B	5.0	3.4	3.6	3.8	145	15	.95
5228	8C	5.0	3.7	3.9	4.1	120	10	.95
5229	8D	5.0	4.0	4.3	4.6	100	5	.95
5230	8E	5.0	4.4	4.7	5.0	80	3	2.0
5231	8F	5.0	4.8	5.1	5.4	60	2	2.0
5232	8G	5.0	5.2	5.6	6.0	40	1	2.0
5233	8H	5.0	5.6	6.0	6.4	25	5	3.3
5234	8J	5.0	5.8	6.2	6.6	10	3	4.0
5235	8K	5.0	6.4	6.8	7.2	15	2	4.0
5236	8L	5.0	7.0	7.5	7.9	15	1	5.0
5237	8M	5.0	7.7	8.2	8.7	15	0.7	5.0
5238	8N	5.0	8.2	8.7	9.2	15	0.6	5.5
5239	8P	5.0	8.5	9.1	9.6	15	0.5	6.0
5240	8Q	5.0	9.4	10	10.6	20	0.2	7.0
5241	8R	5.0	10.4	11	11.6	20	0.1	8.0
5242	8S	5.0	11.4	12	12.7	25	0.1	8.0
5243	8T	5.0	12.4	13	14.1	30	0.1	8.0
5244	8U	5.0	13.2	14	14.8	30	0.1	9.5
5245	8V	5.0	13.8	15	15.6	30	0.05	10.5
5246	8W	5.0	15.3	16	17.1	40	0.05	11.2
5247	8X	5.0	16.0	17	18.0	45	0.05	11.9
5248	8Y	5.0	16.8	18	19.1	45	0.05	12.6
5249	8Z	5.0	17.9	19	20.1	50	0.05	13.3
5250	81A	5.0	18.8	20	21.2	55	0.05	14.0
5251	81B	5.0	20.8	22	23.3	55	0.05	15.4
5252	81C	5.0	22.8	24	25.6	70	0.05	16.8
5253	81D	5.0	23.3	25	26.7	75	0.05	17.5
5254	81E	2.0	25.1	27	28.9	80	0.05	18.9
5255	81F	2.0	26.1	28	29.9	80	0.05	19.6
5256	81G	2.0	28.0	30	32.0	80	0.05	21.0
5257	81H	2.0	30.8	33	35.0	80	0.05	23.1

MXR3866

CASE 345-01, STYLE 1
SOT-89



RF TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	V
Collector-Base Voltage	V_{CBO}	55	V
Emitter-Base Voltage	V_{EBO}	3.5	V
Collector Current — Continuous	I_C	0.4	A
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

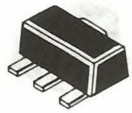
*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 5.0$ mA, $R_{BE} = 10\ \Omega$)	$V_{(BR)CER}$	55	—	V
Collector-Emitter Sustaining Voltage ($I_C = 5.0$ mA)	$V_{CEO(sus)}$	30	—	V
Collector-Base Breakdown Voltage ($I_C = 0.1$ mA)	$V_{(BR)CBO}$	55	—	V
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mA)	$V_{(BR)EBO}$	3.5	—	V
Collector Cutoff Current ($V_{CE} = 28$ V)	I_{CEO}	—	20	μA
Collector Cutoff Current ($V_{CE} = 55$ V, $V_{BE} = 1.5$ V)	I_{CEX}	—	100	μA
ON CHARACTERISTICS				
DC Current Gain ($I_C = 0.36$ A, $V_{CE} = 5.0$ V) ($I_C = 0.05$ A, $V_{CE} = 5.0$ V)	h_{FE}	 5.0 10	 — 200	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mA, $I_B = 20$ mA)	$V_{CE(sat)}$	—	1.0	V
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 50$ mA, $V_{CE} = 15$ V, f = 200 MHz)	f_T	500	—	MHz
Output Capacitance ($V_{CB} = 30$ V, f = 1.0 MHz)	C_{obo}	—	3.0	pF

MXR5160

CASE 345-01, STYLE 1
SOT-89



RF TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	V
Collector-Base Voltage	V_{CBO}	60	V
Emitter-Base Voltage	V_{EBO}	4.0	V
Collector Current — Continuous	I_C	0.4	A
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

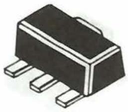
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage ($I_C = 5.0$ mA)	$V_{CEO(sus)}$	40	—	V
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mA)	$V_{(BR)EBO}$	4.0	—	V
Collector Cutoff Current ($V_{CB} = 28$ V)	I_{CBO}	—	1.0	μA
Collector Cutoff Current ($V_{CE} = 60$ V)	I_{CES}	—	0.1	mA
Emitter Cutoff Current ($V_{CE} = 28$ V)	I_{CEO}	—	20	μA
ON CHARACTERISTICS				
DC Current Gain ($I_C = 50$ mA, $V_{CE} = 5.0$ V)	h_{FE}	10	—	—
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 50$ mA, $V_{CE} = 15$ V, f = 200 MHz)	f_T	500	—	MHz

3

MXR5583

CASE 345-01, STYLE 1
SOT-89



HIGH FREQUENCY RF TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	V
Collector-Base Voltage	V_{CBO}	30	V
Emitter-Base Voltage	V_{EBO}	3.0	V
Collector Current — Continuous	I_C	500	mA
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

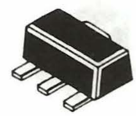
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mA)	$V_{(BR)CEO}$	30	—	V
Collector-Base Breakdown Voltage(1) (I_C = 10 μA)	$V_{(BR)CBO}$	30	—	V
Emitter-Base Breakdown Voltage (I_E = 100 μA)	$V_{(BR)EBO}$	3.0	—	V
Collector Cutoff Current (V_{CB} = 20 V)	I_{CBO}	—	50	nA
Emitter Cutoff Current (V_{EB} = 2.0 V)	I_{EBO}	—	0.5	μA
ON CHARACTERISTICS				
DC Current Gain (I_C = 40 mA, V_{CE} = 2.0 V) (I_C = 100 mA, V_{CE} = 2.0 V) (I_C = 300 mA, V_{CE} = 5.0 V)	h_{FE}	 20 25 15	 — 100 —	—
Collector-Emitter Saturation Voltage (I_C = 100 mA, I_B = 10 mA)	$V_{CE(sat)}$	—	0.8	V
Base-Emitter On Voltage (I_C = 100 mA, V_{CE} = 2.0 V)	$V_{BE(on)}$	—	1.8	V
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 40 mA, V_{CE} = 10 V, f = 100 MHz) (I_C = 100 mA, V_{CE} = 10 V, f = 100 MHz)	f_T	 1000 1300	 — —	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MXR5943

CASE 345-01, STYLE 1
SOT-89



RF TRANSISTOR

NPN SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	V
Collector-Base Voltage	V_{CBO}	40	V
Emitter-Base Voltage	V_{EBO}	3.5	V
Collector Current — Continuous	I_C	400	mA
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

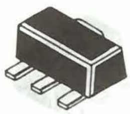
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 5.0 mA)	$V_{(BR)CEO}$	30	—	V
Collector-Base Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CBO}$	40	—	V
Emitter-Base Breakdown Voltage (I_E = 100 μA)	$V_{(BR)EBO}$	3.5	—	V
Collector Cutoff Current (V_{CE} = 20 V)	I_{CEO}	—	50	μA
Collector Cutoff Current (V_{CB} = 15 V)	I_{CBO}	—	10	μA
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mA, V_{CE} = 15 V)	h_{FE}	25	300	—
Collector-Emitter Saturation Voltage (I_C = 100 mA, I_B = 10 mA)	$V_{CE(sat)}$	—	0.2	V
Base-Emitter Saturation Voltage (I_C = 100 mA, I_B = 10 mA)	$V_{BE(sat)}$	—	1.0	V
SMALL SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 25 mA, V_{CE} = 15 V, f = 200 MHz) (I_C = 50 mA, V_{CE} = 15 V, f = 200 MHz) (I_C = 100 mA, V_{CE} = 15 V, f = 200 MHz)	f_T	 1000 1200 1000	 — — —	MHz

3

MXT3904

CASE 345-01, STYLE 1
SOT-89



GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N3904 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltge	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	6.0	—	Vdc
Base Cutoff Current ($V_{CE} = 30$ Vdc, $V_{EB} = 3.0$ Vdc)	I_{BL}	—	50	nAdc
Collector Cutoff Current ($V_{CE} = 30$ Vdc, $V_{EB} = 3.0$ Vdc)	I_{CEX}	—	50	nAdc
ON CHARACTERISTICS				
DC Current Gain(1) ($I_C = 0.1$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	 40 70 100 60 30	 — — 300 — —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{CE(sat)}$	 — —	 0.2 0.3	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{BE(sat)}$	 0.65 —	 0.85 0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	300	—	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	4.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)	C_{ibo}	—	8.0	pF
Input Impedance ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{ie}	1.0	10	k ohms
Voltage Feedback Ratio ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{re}	0.5	8.0	$X\ 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{fe}	100	400	—

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	1.0	40	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohms, f = 10 Hz to 15.7 kHz)	NF	—	5.0	dB

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
Delay Time	(V_{CC} = 3.0 Vdc, V_{BE} = 0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_d	—	35	ns
Rise Time		t_r	—	35	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	t_s	—	200	ns
Fall Time		t_f	—	50	ns

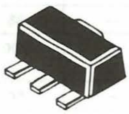
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

3

3

MXT3906

CASE 345-01, STYLE 1
SOT-89



GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

Refer to 2N3905 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Base Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 3.0 Vdc)	I_{BL}	—	50	nAdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 3.0 Vdc)	I_{CEX}	—	50	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 60 80 100 60 30	 — — 300 — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	 — —	 0.25 0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	 0.65 —	 0.85 0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	250	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	4.5	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	10.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	2.0	12	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{re}	0.1	10	X 10^{-4}
Small Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	100	400	—

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	3.0	60	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohm, f = 10 Hz to 15.7 kHz)		NF	—	4.0	dB
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 3.0 Vdc, V_{BE} = 0.5 Vdc I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_d	—	35	ns
Rise Time		t_r	—	35	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	t_s	—	225	ns
Fall Time		t_f	—	75	ns

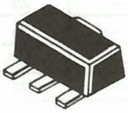
(1) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

3

3

MXTA14

CASE 345-01, STYLE 1
SOT-89



DARLINGTON TRANSISTOR

NPN SILICON

Refer to 2N6426 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	V
Collector-Emitter Voltage	V_{CES}	30	V
Emitter-Base Voltage	V_{EBO}	10	V
Collector Current — Continuous	I_C	300	mV

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

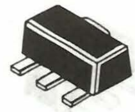
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu A$)	$V_{(BR)CES}$	30	—	V
Collector Cutoff Current ($V_{CB} = 30$)	I_{CBO}	—	100	nA
Emitter Cutoff Current ($V_{BE} = 10$ V)	I_{EBO}	—	100	nA
ON CHARACTERISTICS				
DC Current Gain(1) ($I_C = 10$ mA, $V_{CE} = 5.0$ V) ($I_C = 100$ mA, $V_{CE} = 5.0$ V)	h_{FE}	 10 K 20 K	 — —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 100$ mA, $I_B = 0.1$ mA)	$V_{CE(sat)}$	—	1.5	V
Base-Emitter On Voltage ($I_C = 100$ mA, $V_{CE} = 5.0$ V)	$V_{BE(on)}$	—	2.0	V
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($V_{CE} = 5.0$ V, $I_C = 10$ mA, f = 100 MHz)	f_T	125	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0 %.

MXTA27

CASE 345-01, STYLE 1
SOT-89



DARLINGTON TRANSISTOR

NPN SILICON

Refer to MPSA25 for graphs.

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	60	V
Emitter-Base Voltage	V_{EBO}	10	V
Collector Current — Continuous	I_C	500	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

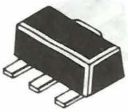
*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu A$)	$V_{(BR)CES}$	60		V
Collector-Base Breakdown Voltage ($I_C = 100\ \mu A$)	$V_{(BR)CBO}$	60	—	V
Collector Cutoff Current ($V_{CB} = 50$ V)	I_{CBO}	—	100	nA
Collector Cutoff Current ($V_{CE} = 50$ V)	I_{CES}	—	500	nA
Emitter Cutoff Current ($V_{BE} = 10$ V)	I_{EBO}	—	100	nA
ON CHARACTERISTICS				
DC Current-Gain ($I_C = 10$ mA, $V_{CE} = 5.0$ V) ($I_C = 100$ mA, $V_{CE} = 5.0$ V)	h_{FE}	 10 K 10 K	— — —	
Collector-Emitter Breakdown Voltage ($I_C = 100$ mA, $I_B = 0.1$ A)	V_{CES}	—	1.5	V
Base-Emitter On Voltage ($I_C = 100$ mA, $V_{CE} = 5.0$ V)	$V_{BE(on)}$	—	2.0	V
SMALL-SIGNAL CHARACTERISTICS				
Current Gain — High Frequency ($I_C = 10$ mA, $V_{CE} = 5.0$ V, f = 100 MHz)	$\lvert h_{fe} \rvert$	1.25	—	—

MXTA42
MXTA43

CASE 345-01, STYLE 1
SOT-89



HIGH VOLTAGE TRANSISTOR

NPN SILICON

Refer to MPSA42 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPSA42	MPSA43	Unit
Collector-Emitter Voltage	V_{CEO}	300	200	Vdc
Collector-Base Voltage	V_{CBO}	300	200	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	6.0	Vdc
Collector Current — Continuous	I_C	500		mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

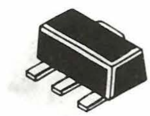
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	MXTA42 MXTA43	$V_{(BR)CEO}$	300 200	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MXTA42 MXTA43	$V_{(BR)CBO}$	300 200	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0) (V_{CB} = 160 Vdc, I_E = 0)	MXTA42 MXTA43	I_{CBO}	— —	0.1 0.1	μAdc
Emitter Cutoff Current (V_{BE} = 6.0 Vdc, I_C = 0) (V_{BE} = 4.0 Vdc, I_C = 0)	MXTA42 MXTA43	I_{EBO}	— —	0.1 0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	Both Types Both Types MXTA42 MXTA43	h_{FE}	25 40 40 40	— — —	—
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	MXTA42 MXTA43	$V_{CE(sat)}$	— —	0.5 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	50	—	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	MXTA42 MXTA43	C_{cb}	— —	3.0 4.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MXTA44

CASE 345-01, STYLE 1
SOT-89



HIGH VOLTAGE TRANSISTOR

NPN SILICON

Refer to MPSA44 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	400	V
Collector-Base Voltage	V_{CBO}	500	V
Emitter-Base Voltage	V_{EBO}	6.0	V
Collector Current — Continuous	I_C	300	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

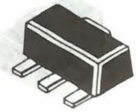
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mA, $I_B = 0$)	$V_{(BR)CEO}$	400	—	V
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu A$, $V_{BE} = 0$)	$V_{(BR)CES}$	500	—	V
Collector-Base Breakdown Voltage ($I_C = 100\ \mu A$, $I_B = 0$)	$V_{(BR)CBO}$	500	—	V
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu A$, $I_C = 0$)	$V_{(BR)EBO}$	6.0	—	V
ON CHARACTERISTICS				
DC Current Gain(1) ($I_C = 1.0$ mA, $V_{CE} = 10$) ($I_C = 10$ mA, $V_{CE} = 10$) ($I_C = 50$ mA, $V_{CE} = 10$) ($I_C = 100$ mA, $V_{CE} = 10$)	h_{FE}	 40 50 45 40	 — 200 — —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 1.0$ mA, $I_B = 0.1$ mA) ($I_C = 10$ mA, $I_B = 1.0$ mA) ($I_C = 50$ mA, $I_B = 5.0$ mA)	$V_{CE(sat)}$	 — — —	 0.4 0.5 0.75	V
Base-Emitter Saturation Voltage ($I_C = 10$ mA, $I_B = 1.0$ mA)	$V_{BE(sat)}$	—	0.75	V
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 20$ V, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	6.0	pF
Input Capacitance ($V_{EB} = 0.5$ V, $I_C = 0$, f = 1.0 MHz)	C_{ibo}	—	110	pF
Current Gain — High Frequency ($I_C = 10$ mA, $V_{CE} = 10$ V, f = 10 MHz)	$\|h_{fe}\|$	2.0	—	—

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0 %.

3

MXTA64

CASE 345-01, STYLE 1
SOT-89



DARLINGTON TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	10	Vdc
Collector Current — Continuous	I_C	300	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

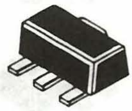
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu A$)	$V_{(BR)CES}$	30	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc)	I_{CBO}	—	100	nA
Emitter Cutoff Current ($V_{BE} = 10$ Vdc)	I_{EBO}	—	100	nAc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 10$ mA, $V_{CE} = 5.0$ Vdc)(1) ($I_C = 100$ mA, $V_{CE} = 5.0$ Vdc)(1)	h_{FE}	 10000 20000	 — —	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mA, $I_B = 0.1$ mA)(1)	$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage ($I_C = 100$ mA, $V_{CE} = 5.0$ Vdc)(1)	$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($V_{CE} = 5.0$ Vdc, $I_C = 100$ mA, f = 100 MHz)	f_T	125	—	MHz

(1) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MXTA77

CASE 345-01, STYLE 1
SOT-89



DARLINGTON TRANSISTOR
PNP SILICON

3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	60	V
Emitter-Base Voltage	V_{EBO}	10	V
Collector Current — Continuous	I_C	300	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

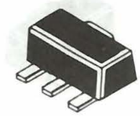
Refer to MPSA75 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CES}$	60	—	V
Collector-Base Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CBO}$	60	—	V
Collector Cutoff Current (V_{CB} = 50 V)	I_{CBO}	—	100	nA
Collector Cutoff Current (V_{CE} = 50 V)	I_{CES}	—	500	nA
Emitter Cutoff Current (V_{BE} = 10 V)	I_{EBO}	—	100	nA
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mA, V_{CE} = 5.0 V) (I_C = 100 mA, V_{CE} = 5.0 V)	h_{FE}	 10 K 10 K	 — —	—
Collector-Emitter Saturation Voltage (I_C = 100 mA, I_B = 0.1 mA)	$V_{CE(sat)}$	—	1.5	V
Base-Emitter On Voltage (I_C = 100 mA, V_{CE} = 5.0 V)	$V_{BE(on)}$	—	2.0	V
Current Gain — High Frequency (I_C = 10 mA, V_{CE} = 5.0 V, f = 100 MHz)	$\|h_{fe}\|$	1.25	—	—

MXTA92
MXTA93

CASE 345-01, STYLE 1
SOT-89



HIGH VOLTAGE TRANSISTOR

PNP SILICON

Refer to MPSA92 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPS-A92	MPS-A93	Unit
Collector-Emitter Voltage	V_{CEO}	300	200	Vdc
Collector-Base Voltage	V_{CBO}	300	200	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc

THERMAL CHARACTERISTICS

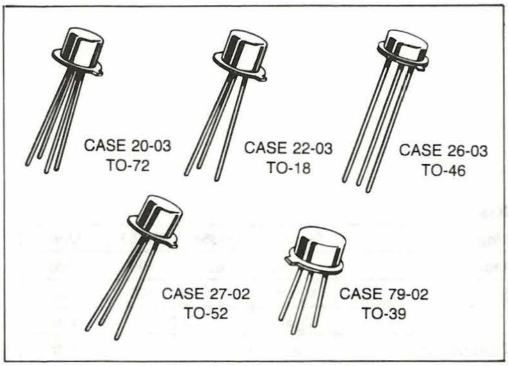
Characteristic	Symbol	Max	Unit
*Total Device Dissipation, T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
*Thermal Resistance Junction to Ambient	$R_{\theta JA}$	125	°C/W

*Package mounted on 99.5% alumina 10 x 12 x 0.6 mm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	MXTA92 MXTA93	$V_{(BR)CEO}$	300 200	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MXTA92 MXTA93	$V_{(BR)CBO}$	300 200	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0) (V_{CB} = 160 Vdc, I_E = 0)	 MXTA92 MXTA93	I_{CBO}	 — —	 0.25 0.25	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	 Both Types Both Types MXTA92 MXTA93	h_{FE}	 25 40 25 25	 — — — 150	—
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	MXTA92 MXTA93	$V_{CE(sat)}$	— —	0.5 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	50	—	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	MXTA92 MXTA93	C_{cb}	— —	6.0 8.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.



Metal Transistors

4

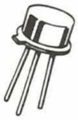
Motorola's metal-can transistor product offering includes: general purpose, switching, high voltage, choppers, Darlingtons, low noise amplifiers and RF amplifiers.

A variety of package options are available: TO-18, TO-46, TO-52, TO-72, and TO-39.

Many devices contained in this section are also available with high reliability MIL-S-19500 processing. JAN, JANTX, JANTXV, and JANS qualified devices are so noted on the following data sheets.

2N656
2N657

CASE 79-02, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N3498 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N656	2N657	Unit
Collector-Emitter Voltage	V_{CEO}	60	100	Vdc
Collector-Base Voltage	V_{CBO}	60	100	Vdc
Emitter-Base Voltage	V_{EBO}	8.0		Vdc
Collector Current — Continuous 2N656 2N657	I_C	 1.0 0.5		Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.7		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	4.0 22.8		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

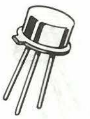
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 250\ \mu Adc$, $I_B = 0$)	 2N656 2N657	$V_{(BR)CEO}$	 60 100	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu Adc$, $I_E = 0$)	 2N656 2N657	$V_{(BR)CBO}$	 60 100	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 250\ \mu Adc$, $I_C = 0$)		$V_{(BR)EBO}$	8.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)		I_{CBO}	—	10	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 200$ mAdc, $V_{CE} = 10$ Vdc)		h_{FE}	30	90	—
Collector-Emitter Saturation Voltage(1) ($I_C = 200$ mAdc, $I_B = 40$ mAdc)		$V_{CE(sat)}$	—	4.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Input Impedance(1) ($I_B = 8.0$ mAdc, $V_{CE} = 10$ Vdc)		h_{ie}	—	0.5	k ohm

(1) Pulse Test: Pulse Length = 300 μs, Duty Cycle ≤ 2.0%.

2N697

CASE 79, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N2218 for graphs.

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CER}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.6 4.0	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.0 13.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 100$ mAdc, $R_{BE} = 10$ ohms)	$V_{(BR)CER}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$) ($V_{CB} = 30$ Vdc, $I_E = 0$, $T_A = 150°C$)	I_{CBO}	 — —	 1.0 100	μAdc
ON CHARACTERISTICS				
DC Current Gain(1) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	40	120	—
Collector-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{BE(sat)}$	—	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$)	C_{obo}	—	35	pF
Small-Signal Current Gain ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)	h_{fe}	2.5	—	MHz

(1) Pulse Test: Pulse Length ≤ 12 ms, Duty Cycle ≤ 2.0%.

2N699

CASE 79, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

4

Refer to 2N3019 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CER}	80	Vdc
Collector-Base Voltage	V_{CBO}	120	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.6 4.0	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.0 13.3	Watts mW/°C
Operating and Storage Temperature Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	75	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	250	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) ($I_C = 100$ mAdc, $R_{BE} \leqq 10$ ohms)	$V_{(BR)CER}$	80	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 60$ Vdc, $I_E = 0$, $T_A = 150°C$)	I_{CBO}	 — —	 2.0 200	μAdc
Emitter Cutoff Current ($V_{EB} = 2.0$ Vdc, $I_C = 0$)	I_{EBO}	—	100	μAdc
ON CHARACTERISTICS				
DC Current Gain (1) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	40	120	—
Collector-Emitter Saturation Voltage (1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{CE(sat)}$	—	5.0	Vdc
Base-Emitter Saturation Voltage (1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{BE(sat)}$	—	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)	f_T	50	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	20	pF
Input Impedance ($I_C = 1.0$ mAdc, $V_{CB} = 5.0$ Vdc, f = 1.0 kHz) ($I_C = 5.0$ mAdc, $V_{CB} = 10$ Vdc, f = 1.0 kHz)	h_{ib}	 20 —	 30 10	Ohms
Voltage Feedback Ratio ($I_C = 1.0$ mAdc, $V_{CB} = 5.0$ Vdc, f = 1.0 kHz) ($I_C = 5.0$ mAdc, $V_{CB} = 10$ Vdc, f = 1.0 khZ)	h_{rb}	 — —	 2.5 3.0	$X\ 10^{-4}$
Small Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{fe}	 35 45	 100 —	—
Output Admittance ($I_C = 1.0$ mAdc, $V_{CB} = 5.0$ Vdc, f = 1.0 kHz) ($I_C = 5.0$ mAdc, $V_{CB} = 10$ Vdc, f = 1.0 kHz)	h_{ob}	 0.05 —	 0.5 1.0	μmhos

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N703

JAN AVAILABLE
CASE 22, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

NPN SILICON

Refer to 2N2368 for graphs.

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 2.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	600 4.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	25	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 5.0 μAdc, I_E = 0)	$V_{(BR)CBO}$	25	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, I_B = 0)	I_{CEO}	—	—	10	μAdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0) (V_{CB} = 10 Vdc, I_E = 0, T_A = +150°C)	I_{CBO}	 — —	 — —	 0.5 50	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, T_A = −55°C)	h_{FE}	 40 20	 — —	 100 —	—
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 0.5 mAdc)	$V_{CE(sat)}$	—	—	0.5	Vdc
Base-Emitter On Voltage(1) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	0.7	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_E = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	70	150	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	3.0	6.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%

4

2N706,A,B

(2N706 JAN AVAILABLE)
CASE 22, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

NPN SILICON

Refer to 2N2368 for graphs.

MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Collector-Emitter Voltage	2N706A,B	V_{CEO}	15	Vdc
Collector-Emitter Voltage(1)		V_{CER}	20	Volts
Collector-Base Voltage		V_{CBO}	25	Volts
Emitter-Base Voltage	2N706 2N706A 2N706B	V_{EBO}	3.0 5.0 5.0	Volts
Collector Current	2N706,A,B	I_C	50	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C		P_D	0.3 2.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C		P_D	1.0 6.67	Watts mW/°C
Total Device Dissipation @ T_C = 100°C Derate above 100°C		P_D	0.5	Watt
Operating and Storage Junction Temperature Range		T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	150	°C/W
Thermal Resistance, Junction to Ambient 2N706A,B	$R_{\theta JA}$	500	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$	15	—	Vdc
Collector-Emitter Breakdown Voltage(2) (R = 10 ohms, I_C = 10 mAdc)		$V_{(BR)CER}$	20	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C) (V_{CB} = 25 Vdc, I_E = 0)	 2N706A, 2N706B	I_{CBO}	 — — —	 0.5 30 10	μAdc
Collector Cutoff Current (V_{CE} = 20 Vdc, R_{BE} = 100k)	 2N706A, 2N706B	I_{CER}	—	10	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0) (V_{EB} = 5.0 Vdc, I_C = 0)	 2N706 2N706A, 2N706B	I_{EBO}	 — —	 10 10	μAdc
ON CHARACTERISTICS					
DC Current Gain(2) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	 2N706 2N706A, 2N706B	h_{FE}	 20 20	 — 60	—
Collector-Emitter Saturation Voltage(2) (I_C = 10 mAdc, I_B = 1.0 mAdc)	 2N706, 2N706A 2N706B	$V_{CE(sat)}$	 — —	 0.6 0.4	Vdc
Base-Emitter Saturation Voltage(2) (I_C = 10 mAdc, I_B = 1.0 mAdc)	 2N706 2N706A, 2N706B	$V_{BE(sat)}$	 — 0.7	 0.9 0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (V_{CE} = 15 Vdc, I_E = 10 mAdc, f = 100 MHz)		f_T	200	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0) (V_{CB} = 10 Vdc, I_E = 0)	 2N706A, 2N706B 2N706	C_{obo}	 — —	 5.0 6.0	pF
Magnitude of Forward Current Transfer Ratio, Common-Emitter (V_{CE} = 15 Vdc, I_E = 10 mAdc, f = 100 Mhz) (V_{CE} = 10 Vdc, I_E = 10 mAdc, f = 100 MHz)	 2N706 2N706A,B	$\|h_{fe}\|$	 2.0 2.0	 — —	—

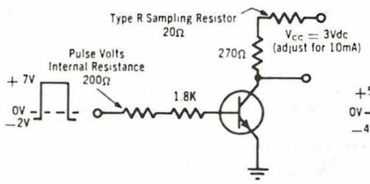
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Collector Base Time Constant (V_{CE} = 15 Vdc, I_E = 10 mAdc, f = 300 MHz)		r_b	—	50	ohms
Storage Time	2N706B	t_s	—	25	ns
Turn-On Time (I_{B1} = 3.0 mA, I_{B2} = 1.0 mA)		t_{on}	—	40	ns
Turn-Off Time (I_{B1} = 3.0 mA, I_{B2} = 1.0 mA)		t_{off}	—	75	ns
Charge Storage Time Constant(2)	2N706	τ_s	—	60	ns
	2N706A,B		—	25	

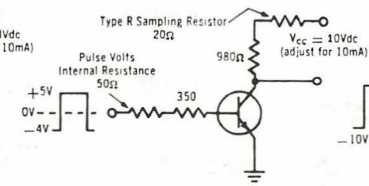
(1) Refers to collector breakdown voltage in the high current region when R_{be} = 10 Ω
(2) Pulse Test: Pulse Width ≤ 12 μs, Duty Cycle ≤ 2.0%.
(3) Switching Times Measured with Tektronix Type R Plug-In (50 Ω Internal Impedance).

4

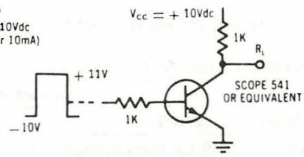
SWITCHING TIME TEST CIRCUIT



STORAGE TIME TEST CIRCUIT



MEASUREMENT CIRCUIT



2N708

JAN, JTX AVAILABLE
CASE 22, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

NPN SILICON

Refer to 2N2368 for graphs.

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage	V_{CER}	20	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	limited by P_D only	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.1	mW mW/°C
Total Device Dissipation @ T_C = 25°C T_C = 100°C Derate above 25°C Derate above 100°C	P_D	1.2 680 6.9 6.9	Watts mW mW/°C mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	145	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 30 mAdc, $R_{BE} \leq$ 10 ohms)	$V_{CER(sus)}$	20	—	Vdc
Collector-Emitter Sustaining Voltage (I_C = 30 mAdc, I_B = 0)	$V_{CEO(sus)}$	15	—	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 0.25 Vdc, T_A = +125°C)	I_{CEX}	—	10	μAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_C = 0, T_A = 150°C)	I_{CBO}	— —	0.025 15	μAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	0.08	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.5 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)(1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C)(1)	h_{FE}	 15 30 15	 — 120 —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 7.0 mAdc, I_B = 0.7 mAdc, T_A = −55°C to +125°C)	$V_{CE(sat)}$	 — —	 0.4 0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 7.0 mAdc, I_B = 0.7 mAdc, T_A = −55°C)	$V_{BE(sat)}$	 0.72 —	 0.80 0.90	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, 100 kHz $\leq$ f $\leq$ 1.0 MHz)	C_{obo}	—	6.0	pF
Extrinsic Base Resistance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 300 MHz)	r_b'	—	50	ohms
SWITCHING CHARACTERISTICS				
Storage Time (I_C = I_{B1} = I_{B2} = 10 mAdc)	t_s	—	25	ns
Turn-On Time	t_{on}	—	40	ns
Turn-Off Time	t_{off}	—	70	ns

2N718

CASE 22, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N2218 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage(1)	V_{CER}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	500	mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.4 2.66	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.5 10	Watts mW/°C
Total Device Dissipation @$T_C = 100°C$	P_D	0.75	Watt
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

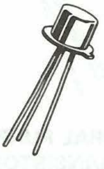
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 100$ mAdc, pulsed; $R_B \leq 10$ Ohms)	$V_{CER(sus)}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 1.0$ mA, $I_C = 0$)	$V_{(BR)EBO}$	5	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$) ($V_{CB} = 30$ Vdc, $I_E = 0$, $T_A = 150°C$)	I_{CBO}	 — —	 1.0 100	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	40	120	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{BE(sat)}$	—	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 10$ Vdc, f = 100 kHz, $I_E = 0$)	C_{obo}	—	35	pF
Input Capacitance ($V_{BE} = 0.5$ V, f = 100 kHz, $I_C = 0$)	C_{ibo}	—	80	pF
Small-Signal Current Gain ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)	h_{fe}	2.5	—	—

(1) Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2.0%.

4

2N718A
2N956, 2N1711

2N718A JAN, JTX, JTXV AVAILABLE
CASE 22, STYLE 1
TO-18 (TO-206AA)



GENERAL PURPOSE TRANSISTOR

NPN SILICON

2N718A: See 2N3019 for graphs.*

MAXIMUM RATINGS

Rating	Symbol	2N718A 2N956	2N1711	Unit
Collector-Emitter Voltage	V_{CER}	50		Vdc
Collector-Base Voltage	V_{CBO}	75		Vdc
Emitter-Base Voltage	V_{EBO}	7.0		Vdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	500 2.86	800 4.57	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.8 10.3	3.0 17.15	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, pulsed; $R_{BE} \leq 10$ ohms)		$V_{CER(sus)}$	50	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		$V_{(BR)CBO}$	75	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	7.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)		I_{CBO}	 — —	 0.001 —	 0.01 10	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	 2N718A, 2N956, 2N1711	I_{EBO}	 — —	 — —	 0.010 0.005	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 0.01 mAdc, V_{CE} = 10 Vdc)	 2N956, 2N1711	h_{FE}	 20	 —	 —	—
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N718A, 2N956, 2N1711		20 35	— —	— —	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N718A, 2N956, 2N1711		35 75	— —	— —	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = −55°C)	2N718A, 2N956, 2N1711		20 35	— —	— —	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	2N718A, 2N956, 2N1711		40 100	— —	120 300	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	2N718A, 2N956, 2N1711		20 40	— —	— —	
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$	—	0.24	1.5	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$	—	1.0	1.3	Vdc

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
*2N956 and 2N1711: See 2N3019 for graphs.

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	2N718A, 2N956, 2N1711	f_T	60 70	300 300	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	4.0	25	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	20	80	pF
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)		h_{ib}	24 4.0	— —	34 8.0	ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	2N718A, 2N956, 2N1711	h_{rb}	— —	— —	3.0 5.0	X 10^{-4}
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	2N718A, 2N956, 2N1711		— —	— —	3.0 5.0	
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N718A, 2N956, 2N1711	h_{fe}	30 50	— —	100 200	—
(I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N718A, 2N956, 2N1711		35 70	— —	150 300	
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)		h_{ob}	0.05 0.05	— —	0.5 0.5	μmhos
Noise Figure (I_C = 300 μAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N718A, 2N956, 2N1711	NF	— —	— —	12 8.0	dB

4

2N720A

CASE 22, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N3019 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Emitter Voltage	V_{CER}	100	Vdc
Collector-Base Voltage	V_{CBO}	120	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.5 2.86	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.8 10.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 100$ mAdc, $R_{BE} \leq 10$ ohms)	$V_{CER(sus)}$	100	—	Vdc
Collector-Emitter Sustaining Voltage(1) ($I_C = 30$ mAdc, $I_B = 0$)	$V_{CEO(sus)}$	80	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	120	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 90$ Vdc, $I_E = 0$) ($V_{CB} = 90$ Vdc, $I_E = 0$, $T_A = 150°C$)	I_{CBO}	— —	.010 15	μAdc
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$)	I_{EBO}	—	.010	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)(1) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, $T_A = -55°C$) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)(1)	h_{FE}	20 35 20 40	— — — 120	—
Collector-Emitter Saturation Voltage(1) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc) ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{CE(sat)}$	— —	1.2 5.0	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc) ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{BE(sat)}$	— —	0.9 1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)	f_T	50	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	15	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)	C_{ibo}	—	85	pF
Input Impedance ($I_C = 1.0$ mAdc, $V_{CB} = 5.0$ Vdc, f = 1.0 kHz) ($I_C = 5.0$ mAdc, $V_{CB} = 10$ Vdc, f = 1.0 kHz)	h_{ib}	20 4.0	30 8.0	Ohms
Voltage Feedback Ratio ($I_C = 1.0$ mAdc, $V_{CB} = 5.0$ Vdc, f = 1.0 kHz) ($I_C = 5.0$ mAdc, $V_{CB} = 10$ Vdc, f = 1.0 kHz)	h_{rb}	— —	1.25 1.50	$X\ 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{fe}	30 45	100 —	—
Output Admittance ($I_C = 1.0$ mAdc, $V_{CB} = 5.0$ Vdc, f = 1.0 kHz) ($I_C = 5.0$ mAdc, $V_{CB} = 10$ Vdc, f = 1.0 kHz)	h_{ob}	— —	0.5 0.5	μmhos

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N834
2N835

CASE 22, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

NPN SILICON

Refer to 2N2368 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous Peak	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.3 2.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 6.67	Watts mW/°C
Total Device Dissipation @ T_C = 100°C Derate above 100°C	P_D	0.5 6.67	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 — —	 0.5 30	μAdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0)	I_{CES}	—	10	μAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	25	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	 — —	 0.25 0.4	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	f_T	350	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	4.0	pF
Magnitude of Forward Current Transfer Ratio, Common-Emitter (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	$\|h_{fe}\|$	3.5	—	—
SWITCHING CHARACTERISTICS				
Charge-Storage Time Constant (Figure 2) (I_C = 10 mAdc, I_{B1} = I_{B2} = 10 mAdc)	t_s	—	25	ns
Turn-On Time (Figure 1) (I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.0 mAdc)	t_{on}	—	35	ns
Turn-Off Time (Figure 1) (I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.0 mAdc)	t_{off}	—	75	ns

(1) Pulse Test: Pulse Width ≤ 12 ms, Duty Cycle ≤ 2.0%.

2N869A
2N4453

JAN, JTX, JTXV AVAILABLE
CASE 22-03, STYLE 1
TO-18 (TO-206AA)

2N4453
CASE 26-03, STYLE 1
TO-46 (TO-206AB)
JAN, JANTX AVAILABLE

SWITCHING TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	2N869A	2N4453	Unit
Collector-Emitter Voltage	V_{CEO}	18	18	Vdc
Collector-Emitter Voltage	V_{CES}	25		Vdc
Collector-Base Voltage	V_{CBO}	25	25	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.06	400 2.29	mW mW/°C
Total Device Dissipation @ T_C = 25°C TC = 100°C Derate above 25°C	P_D	1.2 0.686 6.86	2.0 1.03 11.3	Watts Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N869A	2N4453	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	146	97.5	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	486	585	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	2N4453	$V_{(BR)CEO}$	18	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	2N869A, 2N4453	$V_{(BR)CES}$	25	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mAdc, I_B = 0)		$V_{CEO(sus)}$	18	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N869A, 2N4453	$V_{(BR)CBO}$	25	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)	2N869A	I_{CBO}	—	25	μAdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)		I_{CES}	—	10	nAdc
Emitter Cutoff Current (V_{EB} = 4.5 Vdc, I_C = 0)	2N4453	I_{EBO}	—	10	nAdc
Base Current (V_{CE} = 15 Vdc, V_{BE} = 0)	2N869A	I_B	—	10	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain		h_{FE}			—
(I_C = 10 mAdc, V_{CE} = 0.3 Vdc)	2N869A		30	—	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	2N869A		40	120	
(I_C = 30 mAdc, V_{CE} = 0.5 Vdc)	2N869A, 2N4453		40	120	
(I_C = 30 mAdc, V_{CE} = 0.5 Vdc, T_A = −55°C)	2N869A, 2N4453		17	—	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	2N869A, 2N4453		25	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	2N869A		—	0.15	
(I_C = 30 mAdc, I_B = 1.5 mAdc)	2N4453		—	0.25	
(I_C = 30 mAdc, I_B = 3.0 mAdc)	2N869A		—	0.2	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N869A, 2N4453		—	0.5	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	2N869A		0.78	0.98	
(I_C = 30 mAdc, I_B = 1.5 mAdc)	2N4453		0.8	1.1	
(I_C = 30 mAdc, I_B = 3.0 mAdc)	2N869A		0.85	1.2	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N869A, 2N4453		—	1.7	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1)(2) (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)		f_T	400	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	2N869A	C_{obo}	—	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 150 kHz)	2N869A	C_{ibo}	—	6.0	pF
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	2N4453	C_{cb}	—	6.0	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	2N4453	C_{eb}	—	6.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time	I_C = 30 mAdc, I_{B1} = 1.5 mAdc; V_{CC} = 2.0 Vdc, 2N869A	t_{on}	—	50	ns
Delay Time	I_C = 30 mAdc, I_{B1} = 1.5 mAdc; V_{CC} = 3.0 Vdc 2N4453	t_d	—	35	ns
Rise Time	I_C = 30 mAdc, I_{B1} = 1.5 mAdc; V_{CC} = 3.0 Vdc 2N4453	t_r	—	20	ns
Turn-Off Time	I_C = 30 mAdc, I_{B1} = I_{B2} = 1.5 mAdc; V_{CC} = 2.0 Vdc 2N869A	t_{off}	—	80	ns
Storage Time	I_C = 30 mAdc, I_{B1} = I_{B2} = 1.5 mAdc; V_{CC} = 3.0 Vdc 2N4453	t_s	—	65	ns
Fall Time	I_C = 30 mAdc, I_{B1} = I_{B2} = 1.5 mAdc; V_{CC} = 3.0 Vdc 2N4453	t_f	—	20	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 1.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

4

TYPICAL SWITCHING CHARACTERISTICS

FIGURE 1 — CAPACITANCE

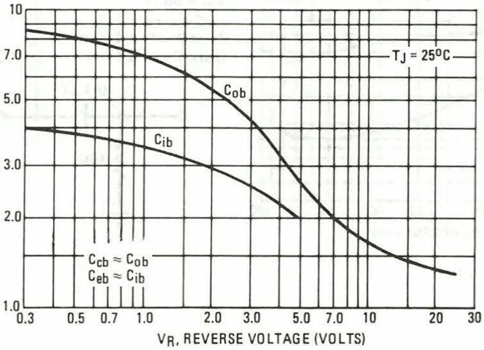


FIGURE 2 — DC CURRENT GAIN

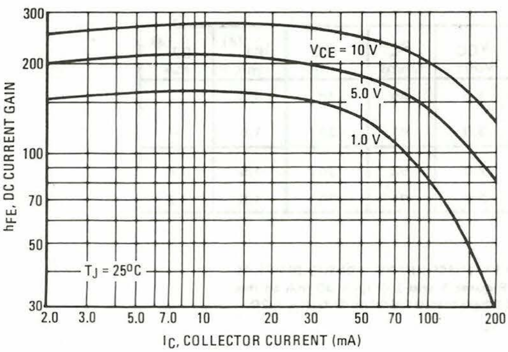


FIGURE 3 — "ON" VOLTAGES

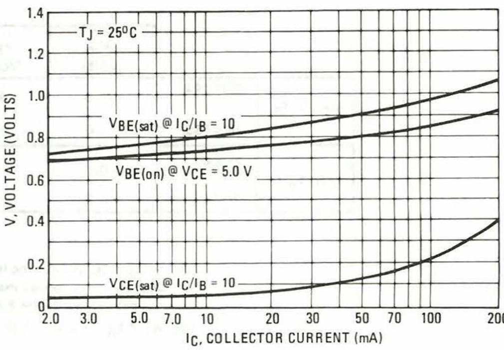


FIGURE 4 — CURRENT-GAIN — BANDWIDTH PRODUCT

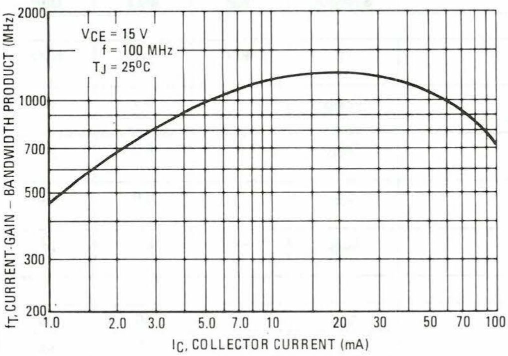


FIGURE 5 — TURN-ON TIME

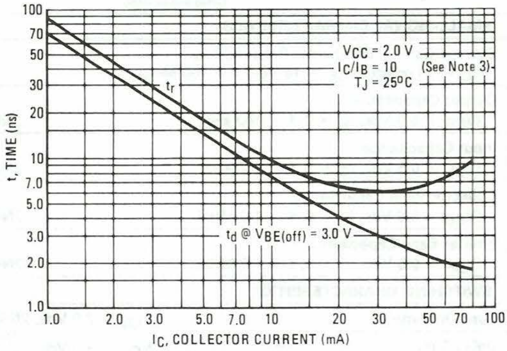


FIGURE 6 — TURN-OFF TIME

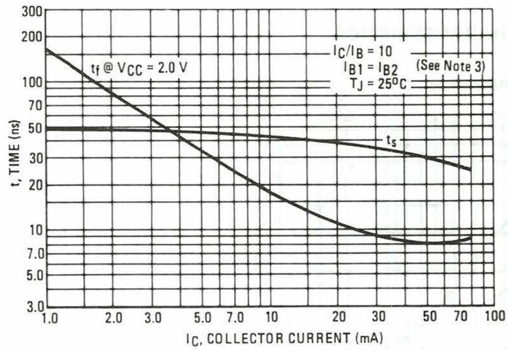


FIGURE 7 — SWITCHING TIME TEST CIRCUIT

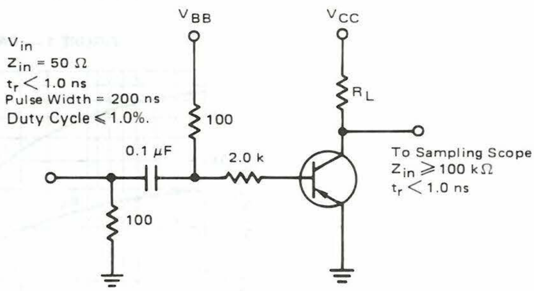


FIGURE 8 — SWITCHING TEST CIRCUIT VALUES

		V_{in} Volts	V_{BB} Volts	V_{CC} Volts	R_L Ohms	I_C mA	I_{B1}(4) mA	I_{B2}(4) mA
t_{on}, t_r, t_d	2N869A	-7.0	3.0	2.0	62	30	1.5	—
	2N4453	-7.0	3.0	3.0	91	30	1.5	—
t_{off}, t_s, t_f	2N869A	+6.0	-4.0	2.0	62	30	1.5	1.5
	2N4453	+6.0	-4.0	3.0	91	30	1.5	1.5

(3) I_C/I_B = 10. Switching is shown to reflect current industry practices. Compare the values shown in Figures 1 and 2 @ I_C = 30 mA to the typical values in the Electrical Characteristics table @ I_C/I_B = 20.

(4) $I_{B1} = I_{B2}$ = 3.0 mA @ I_C/I_B = 10

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Emitter Voltage (R_{BE} = 10 Ohms)	V_{CER}	80	Vdc
Collector-Base Voltage	V_{CBO}	100	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Collector Current — Continuous	I_C	1.0	Amp
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 2.86	Watt mW/°C
Total Device Dissipation @ T_C = 25°C T_C = 100°C Derate above 25°C	P_D	1.8 1.0 10.3	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97.4	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	350	°C/W

2N910

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

4

Refer to 2N3019 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, $R_{BE} \leq$ 10 ohms)(1)	$V_{CER(sus)}$	80	—	Vdc
Collector-Emitter Sustaining Voltage (I_C = 30 mAdc, I_B = 0)(1)	$V_{CEO(sus)}$	60	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	100	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current (V_{CB} = 75 Vdc, I_E = 0) (V_{CB} = 75 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	— —	0.025 15	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	0.025	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = –55°C)	h_{FE}	35 75 30	— — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	— —	0.4 1.2	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	0.6 —	0.8 0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	60	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	85	pF
Input Impedance (I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{ie}	—	1800	Ohms
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ib}	20 4.0	30 8.0	Ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{rb}	—	3.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	76	200	—
Output Admittance (I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{oe}	—	100	μmhos
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ob}	— —	0.5 1.0	μmho
Noise Figure (I_C = 0.3 mAdc, V_{CB} = 10 Vdc, R_G = 510 ohms, f = 1.0 kHz, B W = 200 Hz)	NF	—	12	dB

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.

2N914

JAN, JTX AVAILABLE
CASE 22, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

NPN SILICON

4

Refer to 2N2368 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage ($R_{BE} \leq 10$ ohms)	V_{CER}	20	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous(1)	I_C	150	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	360 2.06	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.2 6.8	Watts mW/°C
Total Device Dissipation @ $T_C = 100°C$ Derate above 100°C	P_D	0.68	Watt
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

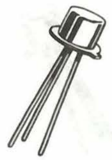
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(2) ($I_C = 30$ mAdc, $R_{BE} \leq 10$ ohms)	$V_{CER(sus)}$	20	—	Vdc
Collector-Emitter Sustaining Voltage(2) ($I_C = 30$ mAdc, $I_B = 0$)	$V_{CEO(sus)}$	15	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 1.0$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 20$ Vdc, $V_{BE} = 0.25$ Vdc, $T_A = 125°C$)	I_{CEX}	—	10	μAdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$) ($V_{CB} = 20$ Vdc, $I_E = 0$, $T_A = 150°C$)	I_{CBO}	— —	0.025 15	μAdc
Emitter Cutoff Current ($V_{BE} = 4.0$ Vdc, $I_C = 0$)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain(2) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc, $T_A = -55°C$) ($I_C = 500$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	 30 12 10	 120 — —	—
Collector-Emitter Saturation Voltage(2) ($I_C = 200$ mAdc, $I_B = 20$ mAdc) ($I_C = 10$ mAdc, $I_B = 1.0$ thru 20 mAdc, $T_A = -55$ to $+125°C$)	$V_{CE(sat)}$	 — —	 0.70 0.25	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	0.70	0.80	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 20$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	300	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	6.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)	C_{ibo}	—	9.0	pF
SWITCHING CHARACTERISTICS				
Storage Time(3) ($I_C = I_{B1} = I_{B2} = 20$ mAdc)	t_s	—	20	ns
Turn-On Time(3) ($I_C = 200$ mAdc, $I_{B1} = 40$ mAdc, $I_{B2} = 20$ mAdc)	t_{on}	—	40	ns
Turn-Off Time(3) ($I_C = 200$ mAdc, $I_{B1} = 40$ mAdc, $I_{B2} = 20$ mAdc)	t_{off}	—	40	ns

(1) Limited by Power Dissipation.
(2) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 1.0%.
(3) Measured on Sampling Scope: Pulse Width ≥ 200 ns.

2N915

CASE 22, STYLE 1
TO-18 (TO-206AA)



GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N3946 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CBO}	70	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.36 2.05	Watts mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.2 6.81	Watts mW/°C
Total Power Dissipation @ + 100°C Case	P_D	0.68	W
Operating and Storage Temperature Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) ($I_C = 10$ mA $I_B = 0$)	$V_{CEO(sus)}$	50	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$A $I_E = 0$)	$V_{(BR)CBO}$	70	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$A, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ V, $I_E = 0$)	I_{CBO}	—	0.010	μA
Collector Cutoff Current ($V_{CB} = 60$ V, $I_E = 0$) ($V_{CB} = 60$ V, $I_E = 0$, $T_A = +150°C$)	I_{CBO}	 — —	 0.010 30	μA
ON CHARACTERISTICS				
DC Current Gain ($I_C = 10$ mA $V_{CE} = 5.0$ V)	h_{FE}	50	200	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mA $I_B = 1.0$ mA	$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mA $I_B = 1.0$ mA)	$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($I_E = 0$ $V_{CB} = 10$ V, f = 100 kHz)	C_{obo}	—	3.5	pF
Emitter Transition Capacitance ($I_C = 0$ $V_{EB} = 0.5$ V, f = 100 kHz)	C_{TE}	—	10	pF
Input Impedance ($I_C = 1.0$ mA $V_{CE} = 5.0$ V) ($I_C = 5.0$ mA $V_{CE} = 5.0$ V)	h_{ie}	 — —	 6000 2000	ohms
High Frequency Current Gain f = 100 MHz ($I_C = 10$ mA $V_{CE} = 15$ V)	h_{fe}	2.5	—	—
Small-Signal Current Gain f = 1 kHz ($I_C = 1.0$ mA $V_{CE} = 5.0$ V) ($I_C = 5.0$ mA $V_{CE} = 5.0$ V)	h_{fe}	 40 50	 200 250	—
Output Admittance ($I_C = 1.0$ mA $V_{CE} = 5.0$ V) ($I_C = 5.0$ mA $V_{CE} = 5.0$ V)	h_{oe}	 — —	 75 125	 μmhos μmho
Collector Base Time Constant ($I_C = 10$ mA, $V_{CB} = 10$ V, f = 40 mHz)	$r_b'C_c$		300	ps

(1) Pulse Test: PW ≦ 300 μs, Duty Cycle ≦ 1.0%.

4

2N916

JAN AVAILABLE
CASE 22, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N3946 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	45	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.36 2.06	Watts mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.2 6.9	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) ($I_C = 30$ mA, $I_B = 0$)	$V_{CEO(sus)}$	25	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu A$, $I_E = 0$)	$V_{(BR)CBO}$	45	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu A$, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ V, $I_E = 0$)	I_{CBO}	—	10	nAdc
Collector Cutoff Current @ 150°C ($V_{CB} = 30$ V, $I_E = 0$)	I_{CBO}	—	10	μAdc
ON CHARACTERISTICS				
DC Current Gain(1) ($I_C = 10$ mA, $V_{CE} = 1.0$ V) ($I_C = 10$ mA, $V_{CE} = 1.0$ V, −55°C)	h_{FE}	 50 15	 200 —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mA, $I_B = 1.0$ mA)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mA, $I_B = 1.0$ mA)	$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 5.0$ V, $I_E = 0$)	C_{obo}	—	6.0	pF
Input Capacitance ($V_{EB} = 0.5$ V, $I_C = 0$)	C_{ibo}	—	10	pF
Input Impedance, f = 1.0 kHz ($I_C = 1.0$ mA, $V_{CE} = 5.0$ V) ($I_C = 5.0$ mA, $V_{CE} = 5.0$ V)	h_{ie}	 — —	 6000 2000	 ohms ohms
Small-Signal Current Gain, f = 1.0 kHz ($I_C = 1.0$ mA, $V_{CE} = 5.0$ V) ($I_C = 5.0$ mA, $V_{CE} = 5.0$ V)	h_{fe}	 40 50	 200 250	—
Magnitude of Forward Circuit Transfer Ratio, Common-Emitter ($I_C = 10$ mA, $V_{CE} = 15$ V)	$\|h_{fe}\|$	3.0	—	—
Output Admittance, f = 1.0 kHz ($I_C = 1.0$ mA, $V_{CE} = 5.0$ V) ($I_C = 5.0$ mA, $V_{CE} = 5.0$ V)	h_{oe}	 — —	 75 125	 μmho μmho
Collector Base Time Constant ($I_C = 10$ mA, $V_{CB} = 10$ V, f = 40 MHz)	$r_{b'}C_c$	—	300	ps

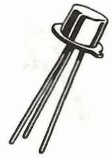
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

2N918

JAN, JTX, JTXV AVAILABLE

CASE 20-03, STYLE 10

TO-72 (TO-206AF)



AMPLIFIER TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 1.71	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 3.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	15	—	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 — —	.010 1.0	μAdc μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	20	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(1) (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	600	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz) (V_{CB} = 0, I_E = 0, f = 140 kHz)	C_{obo}	 — —	 1.7 3.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ibo}	—	2.0	pF
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, R_G = 400 Ohms, f = 60 MHz)	NF	—	6.0	dB
FUNCTIONAL TEST				
Amplifier Power Gain (V_{CB} = 12 Vdc, I_C = 6.0 mAdc, f = 200 MHz)	G_{pe}	15	—	dB
Power Output (V_{CB} = 15 Vdc, I_C = 8.0 mAdc, f = 500 MHz)	P_o	30	—	mW
Collector Efficiency (V_{CB} = 15 Vdc, I_C = 8.0 mAdc, f = 500 MHz)	η	25	—	%

(1) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

2N930,A

JAN, JTX AVAILABLE
CASE 22, STYLE 1
TO-18 (TO-206AA)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N2481 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N930	2N930A	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	Vdc
Collector-Base Voltage	V_{CBO}	45	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	6.0	Vdc
Collector Current	I_C	30		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.5 3.33		W mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.8 12		Watt mW/°C
Operating and Storage Temperature Temperature Range	T_J, T_{stg}	−65 to +175		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$	45	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N930A	$V_{(BR)CBO}$	80	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	2N930 2N930A	$V_{(BR)EBO}$	5.0 6.0	— 	Vdc
Collector Cutoff Current (V_{CE} = 5.0 Vdc, I_B = 0)		I_{CEO}	—	2.0	nAdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)	2N930 2N930A	I_{CBO}	— —	10 2.0	nAdc
Collector Cutoff Current (V_{CE} = 45 Vdc, V_{BE} = 0)	2N930 2N930A	I_{CES}	— —	10 2.0	nAdc
(V_{CE} = 45 Vdc, V_{BE} = 0, T_A = 170°C)	2N930 2N930A		— —	10 2.0	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	2N930 2N930A	I_{EBO}	— —	10 2.0	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 1.0 μAdc, V_{CE} = 5.0 Vdc)	2N930A		60	—	
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	2N930 2N930A		100	300	
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = −55°C)	2N930 2N930A		20 30	— —	
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)	2N930 2N930A		150 —	— —	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (1)	2N930 2N930A		— —	600 600	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 0.5 mAdc)	 2N930 2N930A	$V_{CE(sat)}$	 — —	 1.0 0.5	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 0.5 mAdc)	 2N930 2N930A	$V_{BE(sat)}$	 0.7	 0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 30 MHz)	 2N930 2N930A	f_T	 30 45	 — —	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	 2N930 2N930A	C_{obo}	 — —	 8.0 6.0	pF
Input Impedance (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ib}	25	32	ohms
Voltage Feedback Ratio (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{rb}	—	600	X 10^{-6}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	 2N930 2N930A	h_{fe}	 150	 600	—
Output Admittance (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ob}	—	1.0	μmhos
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 10 Hz to 15.7 kHz)	 2N930, 2N930A	NF	—	3.0	dB

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

4

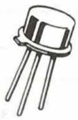
2N956

For Specifications, See 2N718A Data.

4

2N1132,A

JAN AVAILABLE
CASE 79-02, STYLE 1
TO-39 (TO-205AD)



SWITCHING TRANSISTOR

PNP SILICON

Refer to 2N2904 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N1132	2N1132A	Unit
Collector-Emitter Voltage	V_{CEO}	35	40	Vdc
Collector-Emitter Voltage ($R_{BE} \leq 10$ Ohms)	V_{CER}	← 50 →		Vdc
Collector-Base Voltage	V_{CBO}	50	60	Vdc
Emitter-Base Voltage	V_{EBO}	← 5.0 →		Vdc
Collector Current — Continuous	I_C	← 600 →		mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	← 600 → ← 3.43 →		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	← 2.0 → ← 11.43 →		Watts mW/°C
Total Device Dissipation @ $T_C = 100°C$ 2N1132A	P_D	← 1.0 →		Watts
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	87.49	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	291.55	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

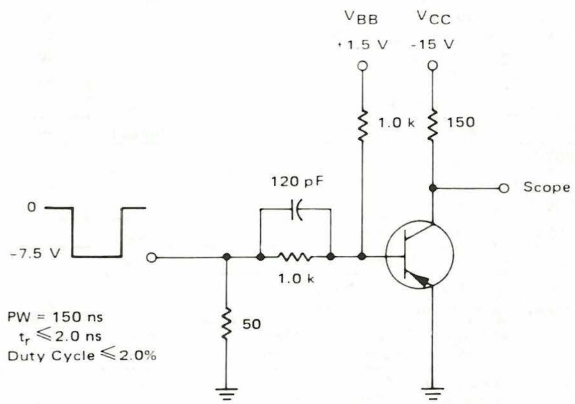
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10$ mA)	2N1132A 2N1132	$V_{(BR)CEO}$	40 35	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	 2N1132, 2N1132A	$V_{(BR)CBO}$	 50 60	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$) ($I_E = 1.0$ mA, $I_C = 0$)	 2N1132, 2N1132A	$V_{(BR)EBO}$	 5.0 5.0	— —	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$) ($V_{CB} = 50$ Vdc, $I_E = 0$) ($V_{CB} = 30$ Vdc, $I_E = 0$, $T_A = 150°C$) ($V_{CB} = 45$ Vdc, $I_E = 0$) ($V_{CB} = 45$ Vdc, $I_E = 0$, $T_A = 150°C$)	 2N1132 2N1132 2N1132 2N1132A 2N1132A	I_{CBO}	 — — — — —	 1.0 100 100 0.5 50	μAdc
Collector Cutoff Current ($V_{CE} = 50$ V, $R_{BE} = \leq 10$ Ohms)	2N1132 2N1132A	I_{CER}	— —	10 10	mA mA
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$) ($V_{BE} = 2.0$ Vdc, $I_C = 0$)	 2N1132A 2N1132	I_{EBO}	 — —	 100 100	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)		h_{FE}	 25 30	 — 90	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)		$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)		$V_{BE(sat)}$	—	1.3	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	60	—	MHz
Output Capacitance		C_{obo}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	2N1132,		—	45	
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	2N1132A		—	30	
Input Capacitance		C_{ibo}			pF
(V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 kHz)	2N1132,		—	80	
(V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	2N1132A		—	80	
Input Impedance		h_{ib}			Ohms
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz			25	35	
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz			—	10	
Voltage Feedback Ratio		h_{rb}			X 10^{-4}
(I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)			—	8.0	
(I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)			—	8.0	
Small-Signal Current Gain		h_{fe}			—
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N1132,		25	100	
	2N1132A		25	75	
(I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N1132,		30	—	
	2N1132A		30		
Output Admittance		h_{ob}			μmhos
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)			—	1.0	
(I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)			—	5.0	
SWITCHING CHARACTERISTICS					
Turn-On Time	2N1132A	t_{on}	—	45	ns
Turn-Off Time	2N1132A	t_{off}	—	35	ns

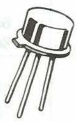
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 SWITCHING TIMES TEST CIRCUIT



2N1613

JAN, JTX, JTXV AVAILABLE
CASE 79-02, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N3019 for graphs.

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage ($R_{BE} \leq 10$ Ohms)	V_{CER}	50	Vdc
Collector-Base Voltage	V_{CBO}	75	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.8 4.57	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	3.0 17.15	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	58.3	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 100$ mAdc, $R_{BE} \leq 10$ Ohms)	$V_{CER(sus)}$	50	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	75	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	7.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 60$ Vdc, $I_E = 0$, $T_A = 150°C$)	I_{CBO}	— —	— —	10 10	nAdc μAdc
Emitter Cutoff Current ($V_{EB} = 5.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	10	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 100\ \mu$Adc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, $T_A = -55°C$) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	20 35 20 40 20	35 50 — 80 30	— — — 120 —	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{CE(sat)}$	—	0.3	1.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{BE(sat)}$	—	0.78	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)	f_T	60	—	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	10	25	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)	C_{ibo}	—	50	80	pF
Input Impedance ($I_C = 1.0$ mAdc, $V_{CB} = 5.0$ Vdc, f = 1.0 kHz) ($I_C = 5.0$ mAdc, $V_{CB} = 10$ Vdc, f = 1.0 kHz)	h_{ib}	24 4.0	— —	34 8.0	Ohms
Voltage Feedback Ratio ($I_C = 1.0$ mAdc, $V_{CB} = 5.0$ Vdc, f = 1.0 kHz) ($I_C = 5.0$ mAdc, $V_{CB} = 10$ Vdc, f = 1.0 kHz)	h_{rb}	— —	— —	3.0 3.0	$X\ 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{fe}	30 35	— —	100 150	—
Output Admittance ($I_C = 1.0$ mAdc, $V_{CB} = 5.0$ Vdc, f = 1.0 kHz) ($I_C = 5.0$ mAdc, $V_{CB} = 10$ Vdc, f = 1.0 kHz)	h_{ob}	0.05 0.05	— —	0.5 0.5	μmhos
Noise Figure ($I_C = 0.3$ mAdc, $V_{CE} = 10$ Vdc, $R_S = 510$ Ohms, f = 1.0 kHz, Bandwidth = 1.0 Hz)	NF	—	—	12	dB
SWITCHING CHARACTERISTICS					
Switching Time	$t_d + t_r + t_f$	—	—	30	ns

(1) Pulse Test: Pulse Width $\leq 300\ \mu$s, Duty Cycle $\leq 2.0\%$.

2N1711 For Specifications, See 2N718A Data.

MAXIMUM RATINGS

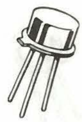
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Emitter Voltage	V_{CER}	100	Vdc
Collector-Base Voltage	V_{CBO}	120	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Collector Current — Continuous	I_C	0.5	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 4.57	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.0 17.2	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	58.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	219	°C/W

2N1893

CASE 79, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTOR
NPN SILICON

Refer to 2N3019 for graphs.

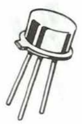
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, R_{BE} = 10 ohms)	$V_{CER(sus)}$	100	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 30 mAdc, I_B = 0)	$V_{CEO(sus)}$	80	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	120	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current (V_{CB} = 90 Vdc, I_E = 0) (V_{CB} = 90 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	— —	0.01 15	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	0.01	μAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 0.1 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = −55°C) (I_C = 150 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20 35 20 40	— — — 120	—
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	— —	1.2 5.0	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	— —	0.9 1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	50	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, 100 kHz ≤ f ≤ 1.0 MHz)	C_{obo}	—	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, 100 kHz ≤ f ≤ 1.0 MHz)	C_{ibo}	—	85	pF
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	h_{ib}	20 4.0	30 8.0	Ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	h_{rb}	— —	1.25 1.5	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	30 45	100 —	—
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	h_{ob}	— —	0.5 0.5	μmho

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N2102

CASE 79-02, STYLE 1
TO-39 (TO-205AD)



AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	65	Vdc
Collector-Emitter Voltage, $R_{BE} \leq 10$ Ohms	V_{CER}	80	Vdc
Collector-Base Voltage	V_{CBO}	120	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	175	°C/W

Refer to 2N3019 for graphs.

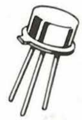
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100$ mAdc, $R_{BE} \leq 10$ ohms)	$V_{CER(sus)}$	80	—	—	Vdc
Collector-Emitter Sustaining Voltage(2) ($I_C = 100$ mAdc, $I_B = 0$)	$V_{CEO(sus)}$	65	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100$ μAdc, $V_{EB} = 1.5$ Vdc)	$V_{(BR)CEX}$	120	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	120	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	7.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 60$ Vdc, $I_E = 0$, $T_A = 150°C$)	I_{CBO}	— —	— —	2.0 2.0	nAdc μAdc
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	2.0	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, $T_A = -55°C$) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)(2) ($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc)(2) ($I_C = 1.0$ Adc, $V_{CE} = 10$ Vdc)(2)	h_{FE}	20 35 20 40 25 10	— — — — — —	— — — 120 — —	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{CE(sat)}$	—	0.15	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{BE(sat)}$	—	0.88	1.1	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)	f_T	60	—	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	6.0	15	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)	C_{ibo}	—	50	80	pF
Input Impedance ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{ib}	24 4.0	— —	34 8.0	Ohms
Voltage Feedback Ratio ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{rb}	— —	— —	3.0 3.0	$X\ 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{fe}	30 35	— —	100 150	—
Output Admittance ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{ob}	0.01 0.01	— —	0.5 1.0	μmho
Noise Figure ($I_C = 300$ μAdc, $V_{CE} = 10$ Vdc, $R_S = 1.0$ k Ohm, f = 1.0 kHz, Bandwidth = 1.0 Hz)	NF	—	4.0	6.0	dB
SWITCHING CHARACTERISTICS					
Switching Time	$t_d + t_r + t_f$	—	—	30	ns

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board. (2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N2193A

CASE 79, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N3019 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CBO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	8.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 4.6	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.8 16	Watts mW/°C
Total Device Dissipation @ 100°C Case Derate above 100°C	P_D	 1.6 16	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 25 mA, I_B = 0)	$V_{CEO(sus)}$	50	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	80	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	8.0	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 — —	 0.010 25	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	0.050	μAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 0.1 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = −55°C) (I_C = 150 mAdc, V_{CE} = 10 Vdc)(1) (I_C = 150 mAdc, V_{CE} = 1.0 Vdc)(1) (I_C = 500 mAdc, V_{CE} = 10 Vdc)(1) (I_C = 1.0 Adc, V_{CE} = 10 Vdc)(1)	h_{FE}	 15 30 20 40 30 20 15	 — — — 120 — — —	—
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	—	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	20	pF
Small-Signal Current Gain (I_C = 50 mA, V_{CE} = 10 V, f = 20 MHz)	h_{fe}	2.5	—	—
SWITCHING CHARACTERISTICS				
Rise Time	t_r	—	70	ns
Storage Time	t_s	—	150	ns
Fall Time	t_f	—	50	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

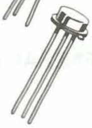
2N2218,A/2N2219,A
2N2221,A/2N2222,A
2N5581/82

JAN, JTX, JTXV AVAILABLE

2N2218,A
2N2219,A
CASE 79-02
TO-39 (TO-205AD) STYLE 1

2N2221,A
2N2222,A
CASE 22-03
TO-18 (TO-206AA) STYLE 1

2N5581
2N5582
CASE 26-03
TO-46 (TO-206AB) STYLE 1



GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N2218 2N2219 2N2221 2N2222	2N2218A 2N2219A 2N2221A 2N2222A	2N5581 2N5582	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	40	Vdc
Collector-Base Voltage	V_{CBO}	60	75	75	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	6.0	6.0	Vdc
Collector Current — Continuous	I_C	800	800	800	mAdc
		2N2218,A 2N2219,A	2N2221,A 2N2222,A	2N5581 2N5582	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.8 4.57	0.4 2.28	0.6 3.33	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	3.0 17.1	1.2 6.85	2.0 11.43	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)	Non-A Suffix A-Suffix, 2N5581, 2N5582	$V_{(BR)CEO}$	30 40	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	Non-A Suffix A-Suffix, 2N5581, 2N5582	$V_{(BR)CBO}$	60 75	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	Non-A Suffix A-Suffix, 2N5581, 2N5582	$V_{(BR)EBO}$	5.0 6.0	— —	Vdc
Collector Cutoff Current ($V_{CE} = 60$ Vdc, $V_{EB(off)} = 3.0$ Vdc)	A-Suffix, 2N5581, 2N5582	I_{CEX}	—	10	nAdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$) ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 50$ Vdc, $I_E = 0$, $T_A = 150°C$) ($V_{CB} = 60$ Vdc, $I_E = 0$, $T_A = 150°C$)	Non-A Suffix A-Suffix, 2N5581, 2N5582 Non-A Suffix A-Suffix, 2N5581, 2N5582	I_{CBO}	— — — —	0.01 0.01 10 10	μAdc
Emitter Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)	A-Suffix, 2N5581, 2N5582	I_{EBO}	—	10	nAdc
Base Cutoff Current ($V_{CE} = 60$ Vdc, $V_{EB(off)} = 3.0$ Vdc)	A-Suffix	I_{BL}	—	20	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 10$ Vdc)	2N2218,A, 2N2221,A, 2N5581(1) 2N2219,A, 2N2222,A, 2N5582(1)	h_{FE}	20 35	— —	—
($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc)	2N2218,A, 2N2221,A, 2N5581 2N2219,A, 2N2222,A, 2N5582		25 50	— —	
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	2N2218,A, 2N2221,A, 2N5581(1) 2N2219,A, 2N2222,A, 2N5582(1)		35 75	— —	
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, $T_A = -55°C$)	2N2218A, 2N2221A, 2N5581 2N2219A, 2N2222A, 2N5582		15 35	— —	
($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)(1)	2N2218,A, 2N2221,A, 2N5581 2N2219,A, 2N2222,A, 2N5582		40 100	120 300	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)(1)	2N2218,A, 2N2221,A, 2N5581		20	—	
	2N2219,A, 2N2222,A, 2N5582		50	—	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	2N2218, 2N2221		20	—	
	2N2219, 2N2222		30	—	
	2N2218A, 2N2221A, 2N5581		25	—	
	2N2219A, 2N2222A, 2N5582		40	—	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	Non-A Suffix		—	0.4	
	A-Suffix, 2N5581, 2N5582		—	0.3	
(I_C = 500 mAdc, I_B = 50 mAdc)	Non-A Suffix		—	1.6	
	A-Suffix, 2N5581, 2N5582		—	1.0	
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	Non-A Suffix		0.6	1.3	
	A-Suffix, 2N5581, 2N5582		0.6	1.2	
(I_C = 500 mAdc, I_B = 50 mAdc)	Non-A Suffix		—	2.6	
	A-Suffix, 2N5581, 2N5582		—	2.0	

SMALL-SIGNAL CHARACTERISTICS

Characteristic		Symbol	Min	Max	Unit
Current-Gain — Bandwidth Product(2)		f_T			MHz
(I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	All Types, Except		250	—	
	2N2219A, 2N2222A, 2N5582		300	—	
Output Capacitance(3) (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	8.0	pF
Input Capacitance(3)		C_{ibo}			pF
(V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	Non-A Suffix		—	30	
	A-Suffix, 2N5581, 2N5582		—	25	
Input Impedance		h_{ie}			kohms
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A, 2N2221A		1.0	3.5	
	2N2219A, 2N2222A		2.0	8.0	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A, 2N2221A		0.2	1.0	
	2N2219A, 2N2222A		0.25	1.25	
Voltage Feedback Ratio		h_{re}			X 10^{-4}
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A, 2N2221A		—	5.0	
	2N2219A, 2N2222A		—	8.0	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A, 2N2221A		—	2.5	
	2N2219A, 2N2222A		—	4.0	
Small-Signal Current Gain		h_{fe}			—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A, 2N2221A		30	150	
	2N2219A, 2N2222A		50	300	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A, 2N2221A		50	300	
	2N2219A, 2N2222A		75	375	
Output Admittance		h_{oe}			μmhos
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A, 2N2221A		3.0	15	
	2N2219A, 2N2222A		5.0	35	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A, 2N2221A		10	100	
	2N2219A, 2N2222A		25	200	
Collector Base Time Constant (I_E = 20 mAdc, V_{CB} = 20 Vdc, f = 31.8 MHz)	A-Suffix	$r_b'C_c$	—	150	ps
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 kohm, f = 1.0 kHz)	2N2219A, 2N2222A	NF	—	4.0	dB
Real Part of Common-Emitter High Frequency Input Impedance (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 300 MHz)	2N2218A, 2N2219A, 2N2221A, 2N2222A	$Re(h_{ie})$	—	60	Ohms

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.
(3) 2N5581 and 2N5582 are Listed C_{cb} and C_{eb} for these conditions and values.

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figure 14)	t_d	—	10	ns
Rise Time		t_r	—	25	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure15)	t_s	—	225	ns
Fall Time		t_f	—	60	ns
Active Region Time Constant (I_C = 150 mAdc, V_{CE} = 30 Vdc) (See Figure 14 for 2N2218A, 2N2219A, 2N2221A, 2N2222A)		T_A	—	2.5	ns

4

FIGURE 1 — NORMALIZED DC CURRENT GAIN

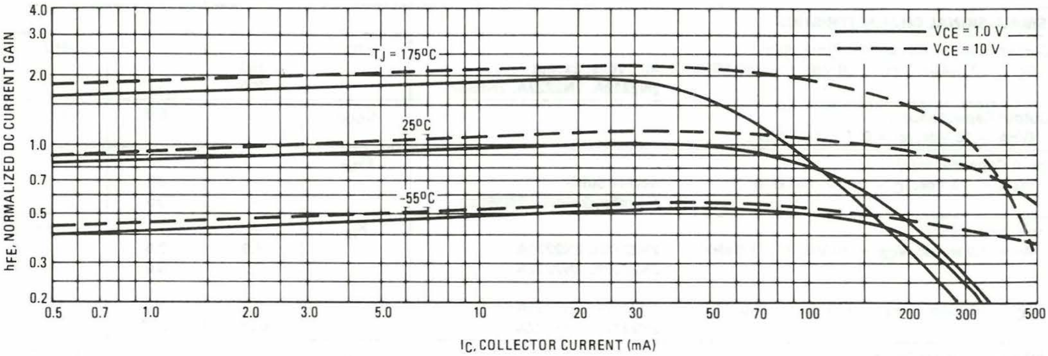
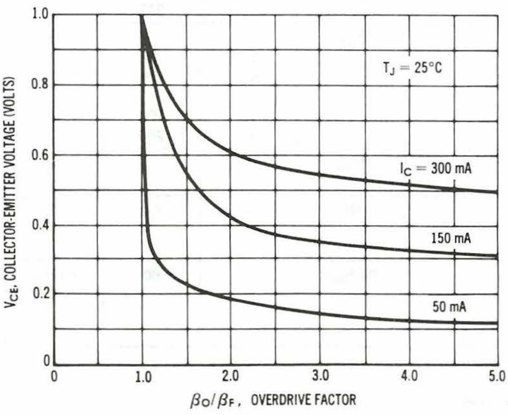


FIGURE 2 — COLLECTOR CHARACTERISTICS IN SATURATION REGION



This graph shows the effect of base current on collector current. β_o (current gain at the edge of saturation) is the current gain of the transistor at 1 volt, and β_F (forced gain) is the ratio of I_C/I_{BF} in a circuit.

EXAMPLE: For type 2N2219, estimate a base current (I_{BF}) to insure saturation at a temperature of 25°C and a collector current of 150 mA.

Observe that at I_C = 150 mA an overdrive factor of at least 2.5 is required to drive the transistor well into the saturation region. From Figure 1, it is seen that h_{FE} @ 1 volt is approximately 0.62 of h_{FE} @ 10 volts. Using the guaranteed minimum gain of 100 @ 150 mA and 10 V, β_o = 62 and substituting values in the overdrive equation, we find:

$$\frac{\beta_o}{\beta_F} = \frac{h_{FE} @ 1.0\,V}{I_C/I_{BF}} \qquad 2.5 = \frac{62}{150/I_{BF}} \qquad I_{BF} \approx 6.0\ mA$$

FIGURE 3 – "ON" VOLTAGES

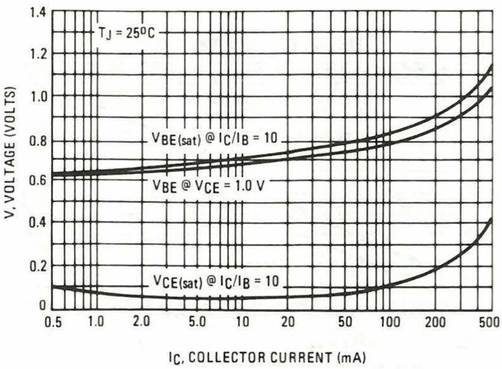
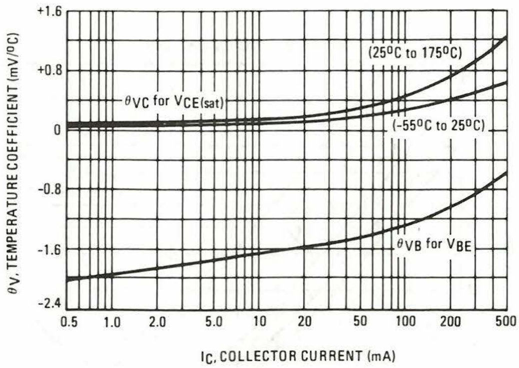


FIGURE 4 – TEMPERATURE COEFFICIENTS



4

h PARAMETERS

V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C

This group of graphs illustrates the relationship between h_{fe} and other "h" parameters for this series of transistors. To obtain these curves, a high-gain and a low-gain unit were selected and the same units were used to develop the correspondingly numbered curves on each graph.

FIGURE 5 — INPUT IMPEDANCE

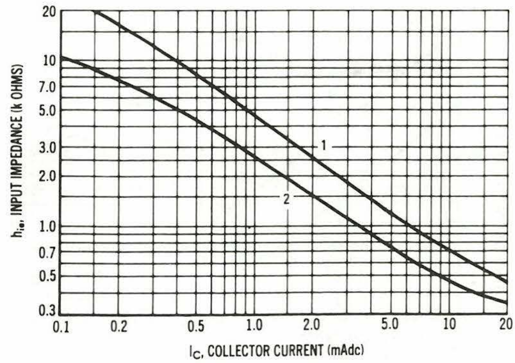


FIGURE 6 — VOLTAGE FEEDBACK RATIO

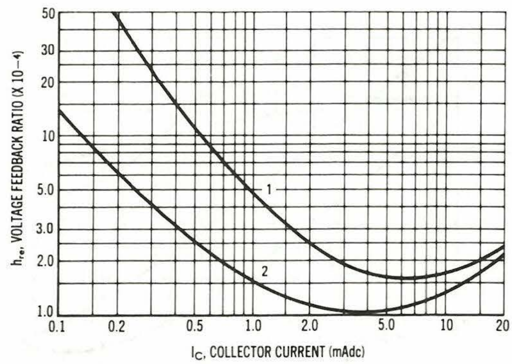


FIGURE 7 — CURRENT GAIN

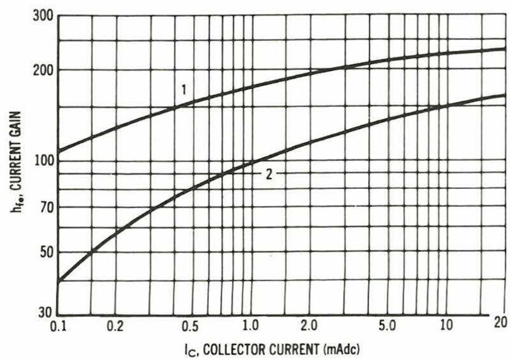
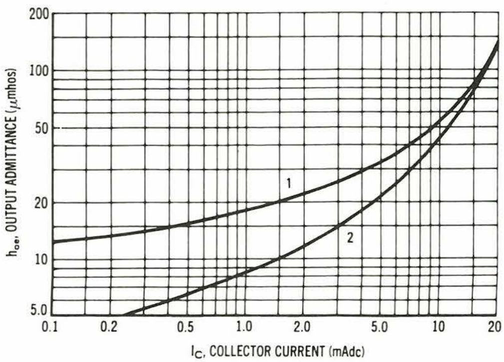


FIGURE 8 — OUTPUT ADMITTANCE



SWITCHING TIME CHARACTERISTICS

FIGURE 9 — TURN-ON TIME

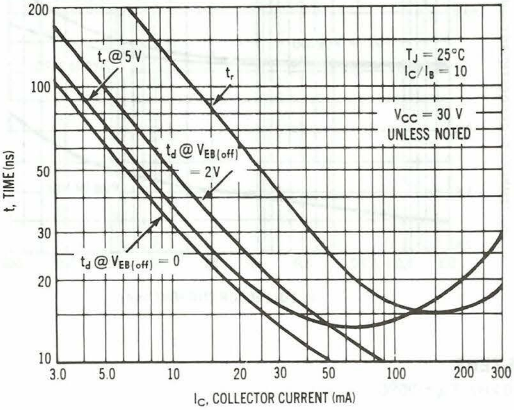


FIGURE 10 — CHARGE DATA

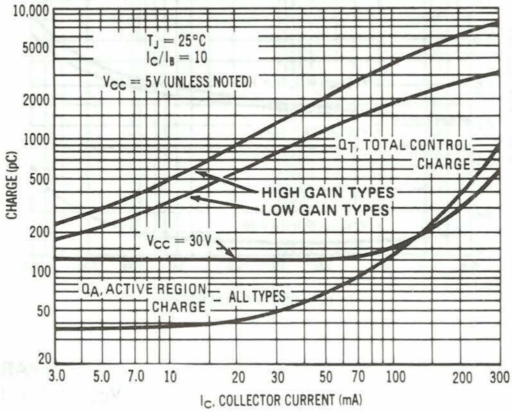


FIGURE 11 — TURN-OFF BEHAVIOR

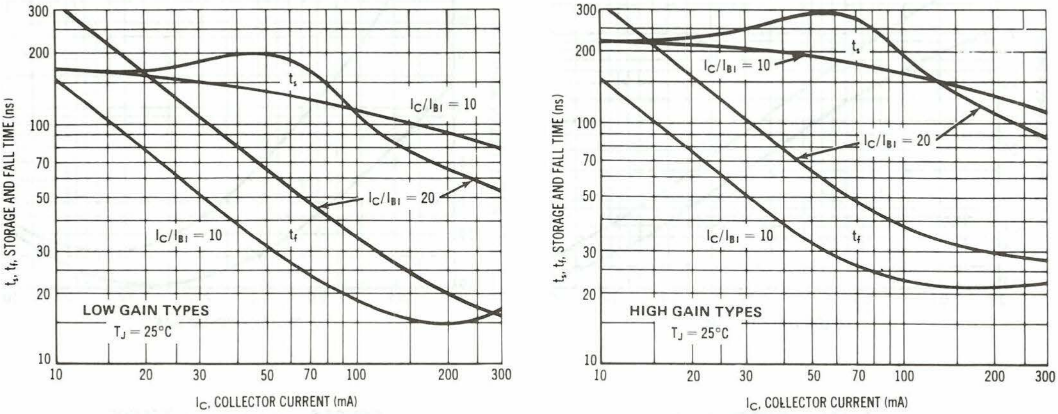


FIGURE 12 — DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

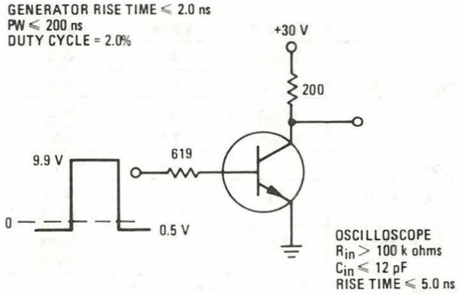
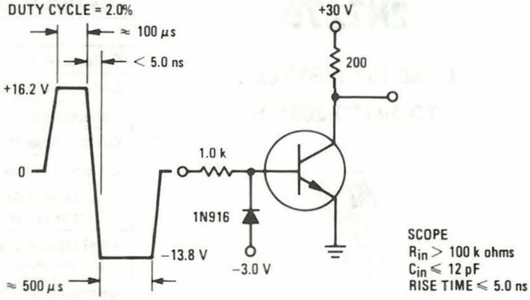


FIGURE 13 — STORAGE TIME AND FALL TIME EQUIVALENT TEST CIRCUIT



4

2N2270

CASE 79-02, STYLE 1

TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N3019 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Emitter Voltage, $R_{BE} \le 10$ Ohms	V_{CER}	60	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	175	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 100$ mAdc, $R_{BE} \le 10$ Ohms)	$V_{(BR)CER}$	60	—	—	Vdc
Collector-Emitter Sustaining Voltage(2) ($I_C = 100$ mAdc, $I_B = 0$)	$V_{CEO(sus)}$	45	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.05$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	7.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$, $T_C = 25°C$) ($V_{CB} = 60$ Vdc, $I_E = 0$, $T_C = 150°C$)	I_{CBO}	— —	— —	0.05 100	μAdc
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	 30 50	 90 135	 — 200	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{CE(sat)}$	—	0.15	0.9	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{BE(sat)}$	—	0.88	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)	f_T	100	250	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	10	15	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)	C_{ibo}	—	60	80	pF
Small-Signal Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{fe}	50	—	275	—
Noise Figure ($I_C = 0.3$ mAdc, $V_{CE} = 10$ Vdc, $R_S = 1.0$ k Ohm, f = 1.0 kHz, B.W. = 1.0 Hz)	NF	—	7.0	10	dB
SWITCHING CHARACTERISTICS					
Total Switching Time	$t_{on} + t_{off}$	—	—	30	ns

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Collector-Base Voltage	V_{CBO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	800 4.56	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	219	°C/W
Lead Temperature, 1/16″ from Case for 10 seconds	T_L	300	°C

2N2297

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

NPN SILICON

4

Refer to 2N3019 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(2) (I_C = 30 mAdc, I_B = 0)	$V_{CEO(sus)}$	35	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	80	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	7.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0, T_A = +150°C)	I_{CBO}	 — —	 — —	 10 10	 nAdc μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	—	10	nAdc
ON CHARACTERISTICS(2)					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc) (I_C = 1.0 Adc, V_{CE} = 10 Vdc)	h_{FE}	 30 40 15	 60 80 40	 — 120 —	—
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 1.0 Adc, I_B = 100 mAdc)	$V_{CE(sat)}$	 — —	 0.1 0.6	 0.2 1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 100 mAdc)	$V_{BE(sat)}$	—	0.8	1.6	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	60	100	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	8.0	12	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	60	80	pF
Collector Base Time Constant (I_C = 10 mAdc, V_{CB} = 10 Vdc, f = 4.0 MHz)	$r_b'C_c$	—	—	800	ps

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

4

2N2368
2N2369,A
2N3227

2N2369A JAN, JTX, JTXV AVAILABLE
CASE 22, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage 2N2368,9,A / 2N3227	V_{CEO}	15 / 20	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage 2N2368,9,A / 2N3227	V_{EBO}	4.5 / 6.0	Vdc
Collector Current (10 μsec pulse)	$I_{C(Peak)}$	500	mA
Collector Current — Continuous 2N2369A, 2N3227	I_C	200	mA
Total Device Dissipation @ T_A = 25°C / Derate above 25°C	P_D	0.36 / 2.06	Watt / mW/°C
Total Device Dissipation @ T_C = 25°C / Derate above 25°C 2N3227	P_D	1.2 / 6.85	Watts / mW/°C
Total Device Dissipation @ T_C = 100°C / Derate above 100°C	P_D	.68 / 6.85	Watts / mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, V_{BE} = 0)	2N3227	$V_{(BR)CEO}$	20	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μA, V_{BE} = 0)		$V_{(BR)CES}$	40	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mAdc, I_B = 0)	2N2368, 2N2369, 2N2369A	$V_{CEO(sus)}$	15	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μA, I_B = 0)		$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_E = 0)	2N2368, 2N2369, 2N2369A	$V_{(BR)EBO}$	4.5	—	Vdc
	2N3227		6.0	—	
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 3.0 Vdc)	2N3227	I_{CEX}	—	0.2	μAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	2N2368, 2N2369	I_{CBO}	—	0.4	μAdc
	2N3227		—	0.2	
(V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)	2N2368, 2N2369, 2N2369A		—	30	
	2N3227		—	50	
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 0)	2N2369A	I_{CES}	—	0.4	μAdc
Base Current (V_{CE} = 20 Vdc, V_{BE} = 0)	2N2369A	I_B	—	0.4	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N2368	h_{FE}	20	60	—
	2N2369		40	120	
	2N2369A		—	120	
	2N3227		100	300	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C)	2N2368		10	—	
	2N2369		20	—	
	2N3227		40	—	
(I_C = 10 mAdc, V_{CE} = 0.35 Vdc, T_A = −55°C)	2N2369A		20	—	
(I_C = 30 mAdc, V_{CE} = 0.4 Vdc)	2N2369A		30	—	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	2N2369A 2N3227		20 30	— —	
(I_C = 100 mAdc, V_{CE} = 2.0 Vdc)	2N2368 2N2369		10 20	— —	
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc)	 2N2368, 2N2369, 2N3227 2N2369A	$V_{CE(sat)}$	 — —	 0.25 0.20	Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = +125°C) (I_C = 30 mAdc, I_B = 3.0 mAdc)	2N2369A 2N2369A		— —	0.30 0.25	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N2369A 2N3227		— —	0.50 .45	
Base-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = +125°C) (I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = −55°C) (I_C = 30 mAdc, I_B = 3.0 mAdc)	 All Types 2N2369A 2N2369A 2N2369A	$V_{BE(sat)}$	 0.70 0.59 — —	 0.85 — 1.02 1.15	Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)	2N2369A 2N3227		— 0.8	1.60 1.4	

SMALL-SIGNAL CHARACTERISTICS

Characteristic		Symbol	Min	Max	Unit
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	 2N2368 2N2369, 2N2369A, 2N3227	f_T	 400 500	 — —	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	 All Types	C_{obo}	—	4.0	pF
Input Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 140 kHz)	 2N3227	C_{ibo}	—	4.0	pF

SWITCHING CHARACTERISTICS

Characteristic			Symbol	Min	Max	Unit
Delay Time	(V_{CC} = 10 V, V_{EB} = 2.0 Vdc, 100 mA, I_{B1} = 10 mA)	2N3227	t_d	—	5.0	ns
Rise Time			t_r	—	18	ns
Storage Time (I_C = I_{B1} = 10 mAdc, I_{B2} = −10 mAdc) (I_C = 100 mAdc, I_{B1} = I_{B2} = 10 mAdc, V_{CC} = 10 V)		 2N2368 2N2369A 2N3227	t_s	 — — —	 10 13 13	ns
Fall Time (V_{CC} = 10 V, I_C = 100 mA, I_{B1} = I_{B2} = 10 mA)		 2N3227	t_f	—	15	ns
Turn-On Time (I_C = 10 mAdc, I_{B1} = 3.0 mA, I_{B2} = −1.5 mA, V_{CC} = 3.0 Vdc)		 All Types	t_{on}	—	12	ns
Turn-Off Time (I_C = 10 mAdc, I_{B1} = 3.0 mA, I_{B2} = −1.5 mA, V_{CC} = 3.0 Vdc)		 2N2368 2N2369, 2N2369A, 2N3227	t_{off}	 — — — —	 — — 15 18	ns
Total Control Charge (I_C = 10 mA, I_B = 1.0 mA, V_{CC} = 3.0 V)		 2N3227	Q_T	—	50	pC

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

4

SWITCHING TIME EQUIVALENT TEST CIRCUITS FOR 2N2369, 2N3227

4

FIGURE 1 — t_{on} CIRCUIT — 10 mA

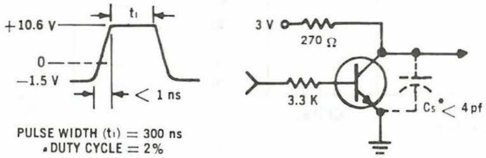


FIGURE 3 — t_{off} CIRCUIT — 10 mA

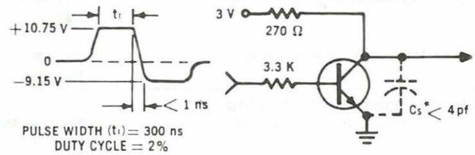


FIGURE 2 — t_{on} CIRCUIT — 100 mA

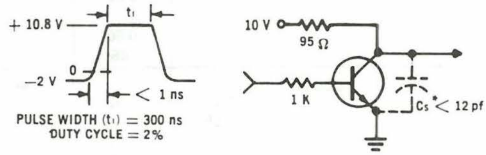
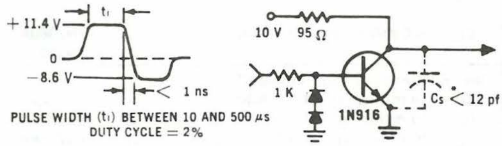


FIGURE 4 — t_{off} CIRCUIT — 100 mA



* Total shunt capacitance of test jig and connectors.

FIGURE 5 — TURN-ON AND TURN-OFF TIME TEST CIRCUIT

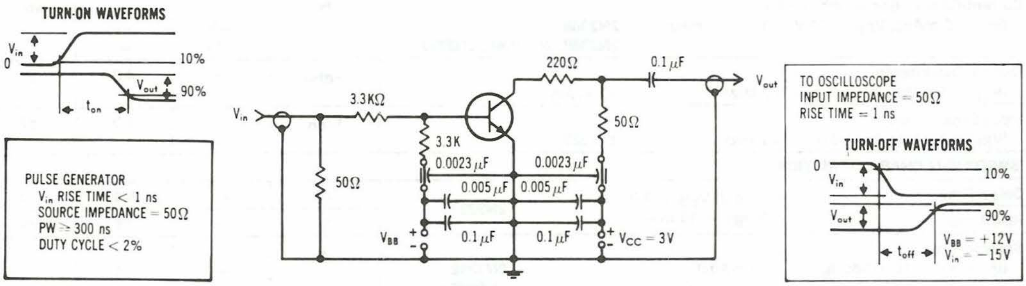


FIGURE 6 — JUNCTION CAPACITANCE VARIATIONS

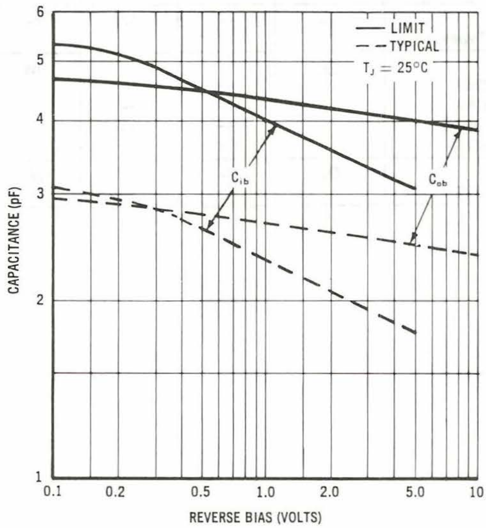


FIGURE 7 — TYPICAL SWITCHING TIMES

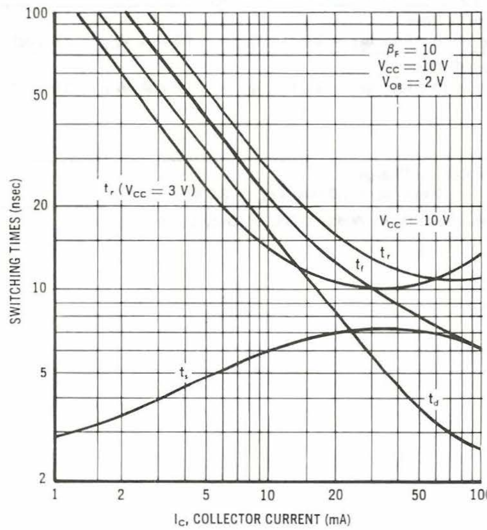


FIGURE 8 — MAXIMUM CHARGE DATA

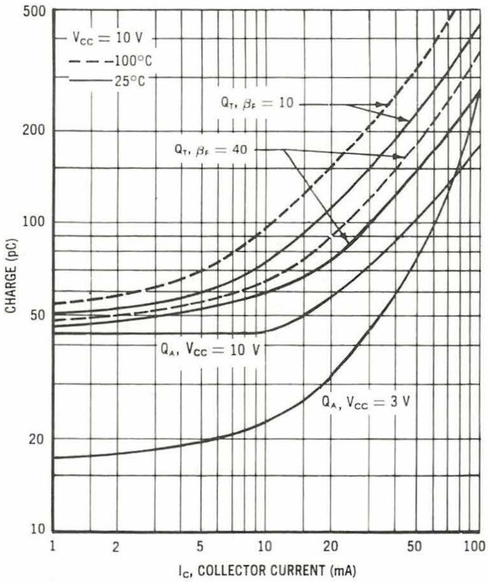


FIGURE 9 — Q_T TEST CIRCUIT

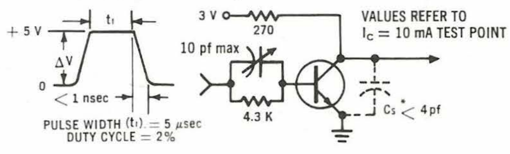


FIGURE 10 — TURN-OFF WAVE FORM

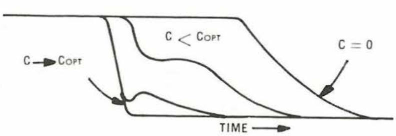


FIGURE 11 — STORAGE TIME EQUIVALENT TEST CIRCUIT

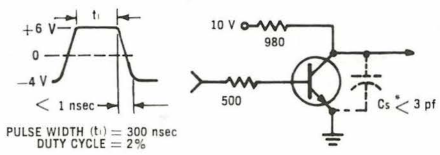


FIGURE 12 — MAXIMUM COLLECTOR SATURATION VOLTAGE CHARACTERISTICS

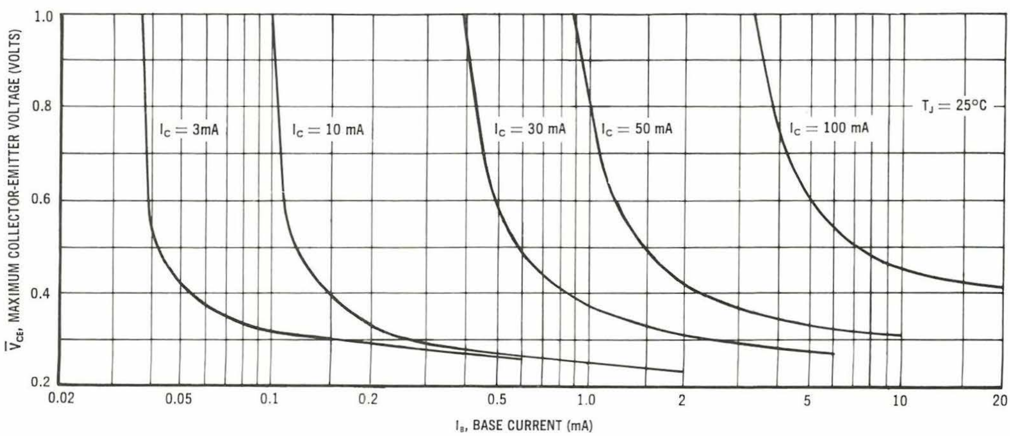


FIGURE 13 — MINIMUM CURRENT GAIN CHARACTERISTICS

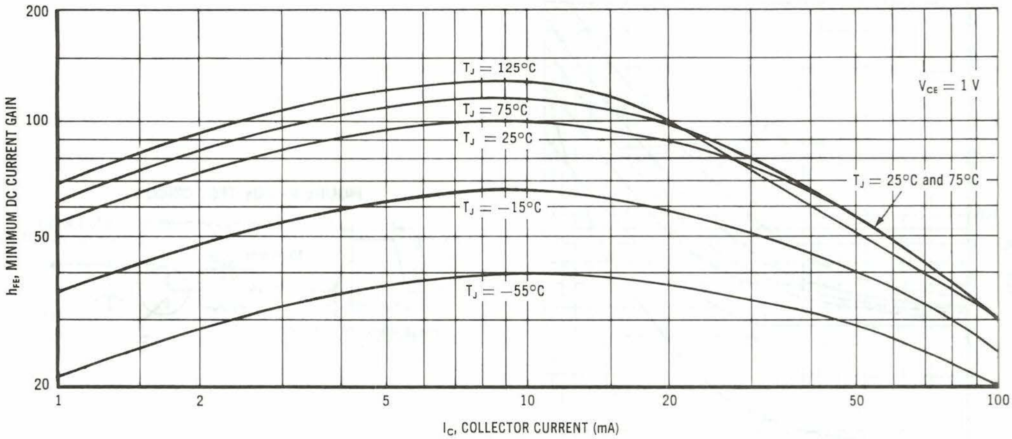


FIGURE 14 — SATURATION VOLTAGE LIMITS

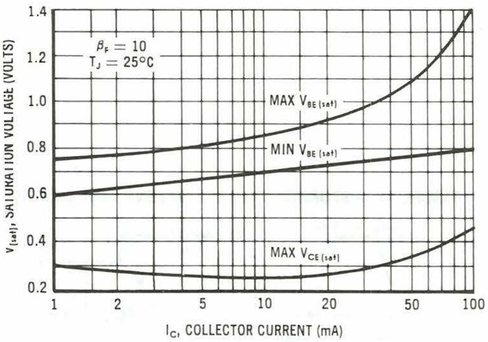
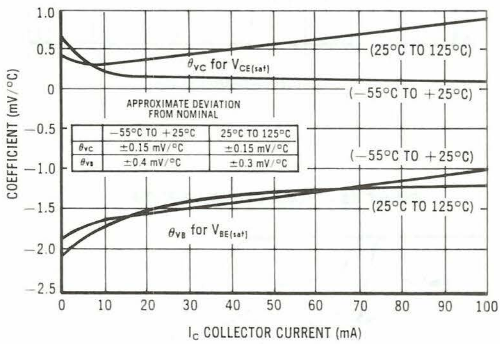


FIGURE 15 — TYPICAL TEMPERATURE COEFFICIENTS



2N2481

JAN, JTX AVAILABLE
CASE 22, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.2 6.9	Watts
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 30$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	15	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ μAdc, $V_{BE} = 0$)	$V_{(BR)CES}$	30	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 20$ Vdc, $V_{BE} = 3.0$ Vdc) ($V_{CE} = 20$ Vdc, $V_{BE} = 3.0$ Vdc, $T_A = 150°C$)	I_{CEX}	 — —	 0.05 15	μAdc
Emitter Cutoff Current ($V_{EB} = 4.0$ Vdc, $I_C = 0$)	I_{EBO}	—	100	nAdc
Base Cutoff Current ($V_{CE} = 20$ Vdc, $V_{BE} = 3.0$ Vdc)	I_{BL}	—	50	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc, $T_A = -55°C$)(1) ($I_C = 150$ mAdc, $V_{CE} = 1.0$ Vdc)(1)	h_{FE}	 25 40 20 20	 — 120 — —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 100$ mAdc, $I_B = 10$ mAdc)(1)	$V_{CE(sat)}$	 — —	 0.25 0.40	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 100$ mAdc, $I_B = 10$ mAdc)(1)	$V_{BE(sat)}$	 0.7 —	 0.82 1.25	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 5.0$ V, $I_C = 0$, f = 1.0 MHz)	C_{obo}	—	5.0	pF
Input Capacitance ($V_{EB} = 0.5$ V, f = 1.0 MHz)	C_{ibo}	—	7.0	pF
Small-Signal Current Gain ($V_{CE} = 10$ V, $I_C = 10$ mA, f = 100 MHz)	h_{fe}	3.0	—	—
Real Part of Input Impedance ($I_C = 10$ mA, $V_{CE} = 10$ V, f = 250 MHz)	$Re(h_{ie})$	—	60	Ohms

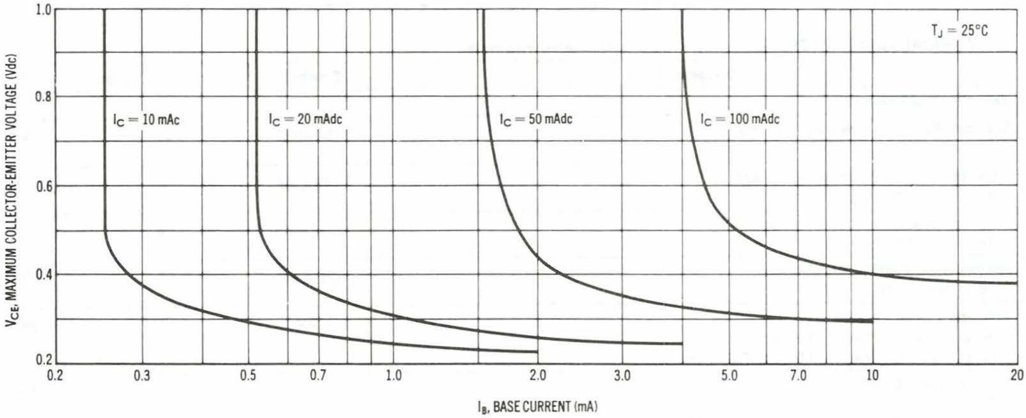
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS				
Storage Time (I_C = 10 mA, I_{B1} = 10 mA, I_{B2} = 10 mA)	t_s	—	20	ns
Turn-On Time	t_{on}			ns
(I_C = 100 mA, I_{B1} = 10 mA, $V_{BE(off)}$ = 2.0 V)		—	40	
(I_C = 10 mA, I_{B1} = 1.0 mA, $V_{BE(off)}$ = 2.0 V)		—	75	
Turn-Off Time	t_{off}			ns
(I_C = 100 mA, I_{B1} = 10 mA, I_{B2} = 5.0 mA)		—	55	
(I_C = 10 mA, I_{B1} = 1.0 mA, I_{B2} = 0.5 mA)		—	45	

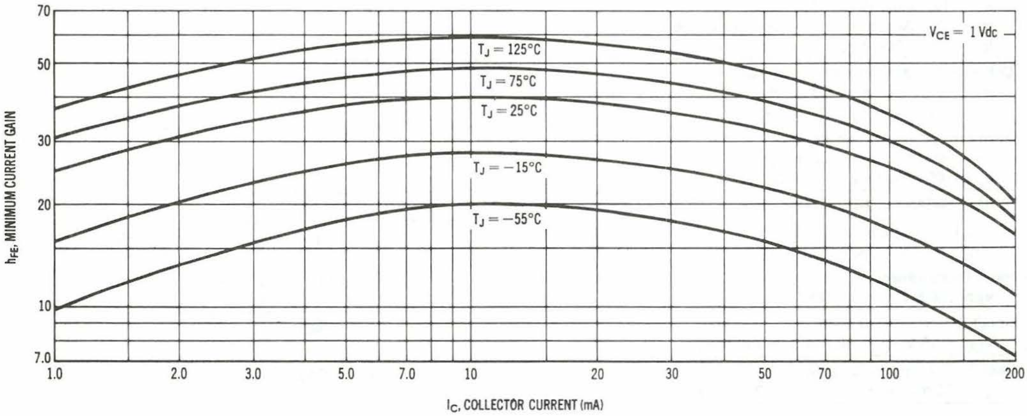
(1) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

4

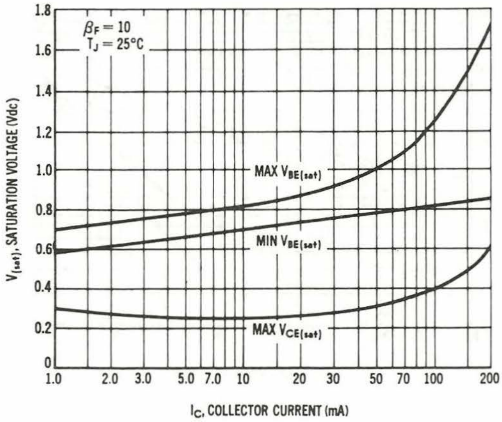
COLLECTOR SATURATION VOLTAGE CHARACTERISTICS



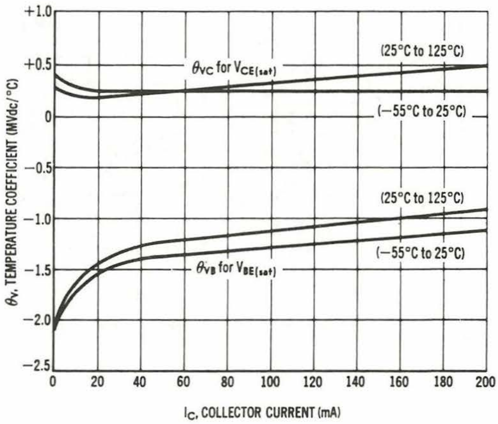
MINIMUM CURRENT GAIN CHARACTERISTICS



LIMITS OF SATURATION VOLTAGES

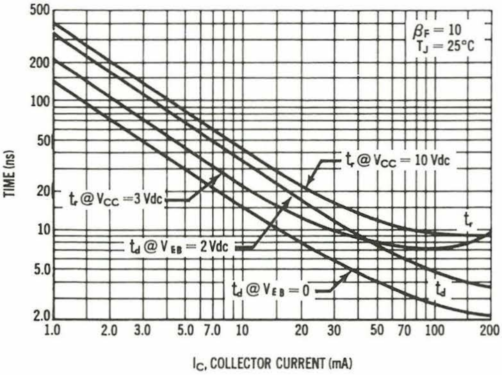


TYPICAL TEMPERATURE COEFFICIENTS

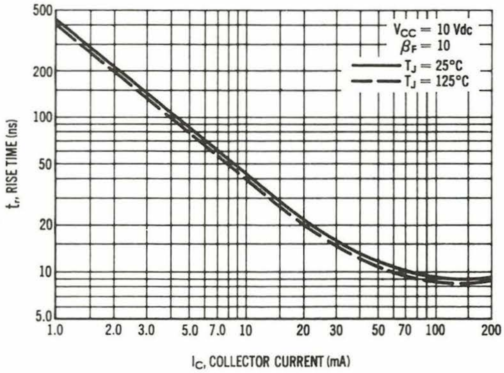


TYPICAL SWITCHING CHARACTERISTICS

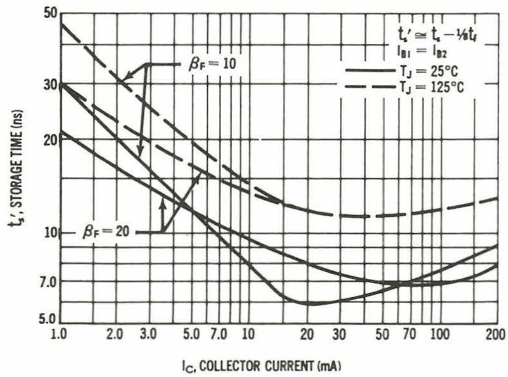
TURN-ON TIME VARIATIONS WITH VOLTAGE



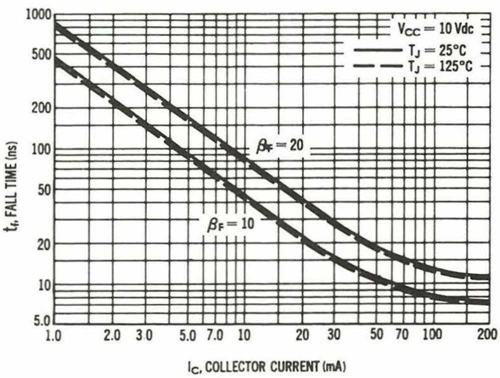
RISE TIME BEHAVIOR



STORAGE TIME BEHAVIOR

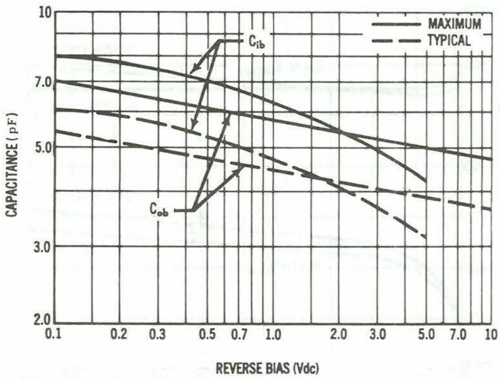


FALL TIME BEHAVIOR

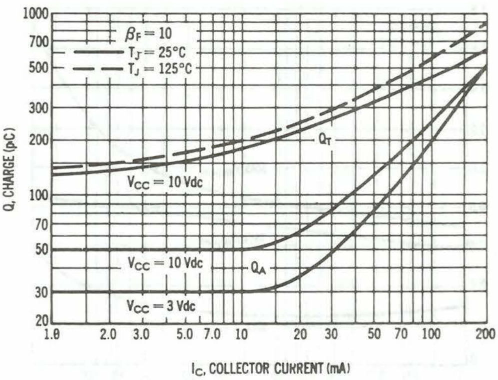


4

JUNCTION CAPACITANCE VARIATIONS



MAXIMUM CHARGE DATA



4

2N2484

JAN, JTX, JTXV AVAILABLE
CASE 22-03, STYLE 1
TO-18 (TO-206AA)

AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	360 2.06	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.2 6.85	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	146	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	485	°C/W
Lead Temperature 1/16″ from Case for 10 Seconds	T_L	300	°C

Refer to 2N2481 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

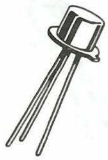
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	60	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 45$ Vdc, $I_E = 0$) ($V_{CB} = 45$ Vdc, $I_E = 0$, $T_A = 150°C$)	I_{CBO}	— —	— —	10 10	nAdc μAdc
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	10	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0$ μAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc, $T_A = 55°C$) ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 500$ μAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)(1)	h_{FE}	30 100 20 175 200 250 —	190 250 40 275 300 350 400	— 500 — — — — 800	—
Collector-Emitter Saturation Voltage ($I_C = 1.0$ mAdc, $I_B = 0.1$ mAdc)	$V_{CE(sat)}$	—	0.25	0.35	Vdc
Base-Emitter On Voltage ($I_C = 0.1$ mAdc, $V_{CE} = 5.0$ Vdc)	$V_{BE(on)}$	0.5	0.65	0.7	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 0.05$ mAdc, $V_{CE} = 5.0$ Vdc, f = 5.0 MHz) ($I_C = 0.5$ mAdc, $V_{CE} = 5.0$ Vdc, f = 30 MHz)	f_T	15 60	50 100	— —	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 140 kHz)	C_{obo}	—	3.0	6.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 140 kHz)	C_{ibo}	—	4.0	6.0	pF
Input Impedance ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz)	h_{ie}	3.5	—	24	kΩ
Voltage Feedback Ratio ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz)	h_{re}	—	—	800	$X\ 10^{-6}$
Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz	h_{fe}	150	—	900	—
Output Admittance ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz)	h_{oe}	—	—	40	μmhos
Noise Figure ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ kΩ, f = 100 Hz, BW = 20 Hz) ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ kΩ, f = 1.0 kHz, BW = 200 Hz) ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ kΩ, f = 10 kHz, BW = 2.0 kHz) ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ kΩ, f = 10 Hz to 15.7 kHz, BW = 15.7 kHz)	NF	— — — —	8.0 — — —	10 3.0 2.0 3.0	dB

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

4

2N2501

CASE 22, STYLE 1
TO-18 (TO-206AA)



SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.1	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.9	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

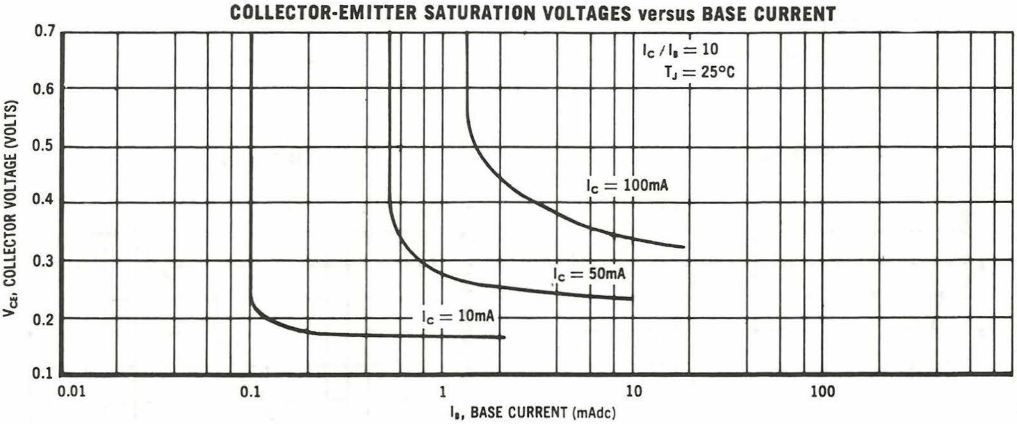
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 30 mAdc, I_B = 0, Pulsed)	$V_{(BR)CEO}$	20	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 3.0 Vdc)	I_{CEX}	—	25	nAdc
Base Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 3.0 Vdc) (V_{CE} = 20 Vdc, V_{BE} = 3.0 Vdc, T_A = 150°C)	I_{BL}	 — —	 0.025 50	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 100 μAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	 20 30 50 20 40 30 10	 — — 150 — — — —	—
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	 — — —	 0.2 0.3 0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	 — — —	 0.85 1.0 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (V_{CE} = 20 Vdc, I_C = 10 mAdc, f = 100 MHz)	f_T	350	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	4.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	7.0	pF
Small-Signal Current Gain (V_{CE} = 20 Vdc, I_C = 10 mAdc, f = 100 MHz)	h_{fe}	3.5	—	—

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

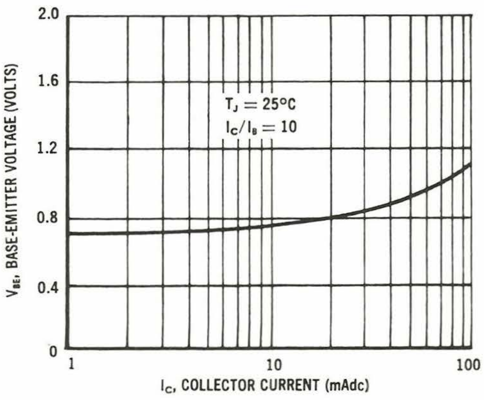
Characteristic	Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS				
Charge Storage Time Constant ($I_C = I_{B1} = I_{B2}$ = 10 mAdc)	τ_S	—	15	ns
Total Control Charge (I_C = 10 mAdc, I_B = 1.0 mAdc)	Q_T	—	60	pC
Active Region Time Constant (I_C = 10 mAdc)	τ_A	—	2.5	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

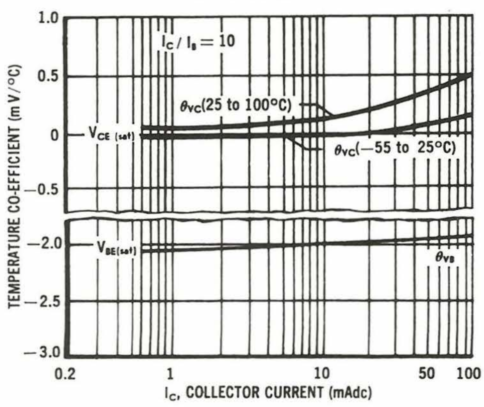
COLLECTOR-EMITTER SATURATION VOLTAGES versus BASE CURRENT



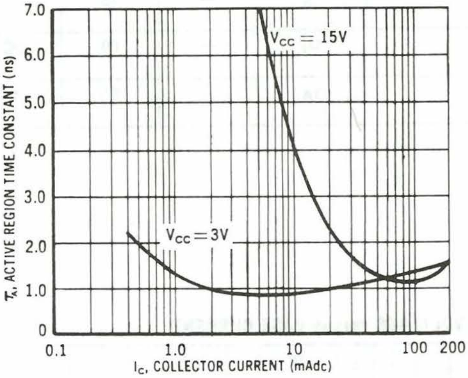
BASE-EMITTER VOLTAGE versus COLLECTOR CURRENT



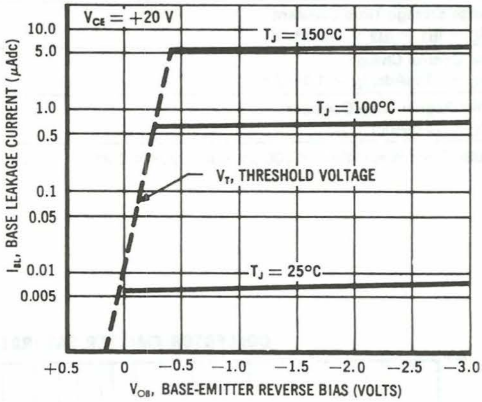
TEMPERATURE COEFFICIENTS



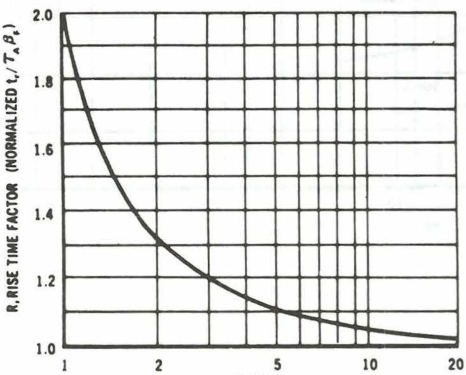
ACTIVE REGION TIME CONSTANT



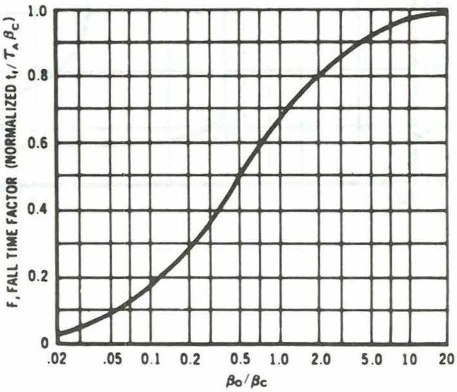
COMMON EMITTER DC LEAKAGE CHARACTERISTICS



RISE TIME FACTOR



FALL TIME FACTOR



2N2539

CASE 22, STYLE 1
TO-18

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Emitter Voltage	V_{CER}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.5 2.86	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.8 10.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 100$ mAdc, pulsed, $I_B = 0$)	$V_{(BR)CEO}$	30	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100$ mAdc, pulsed, $R_{BE} \leq 10\ \Omega$)	$V_{(BR)CER}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{BE} = 0.2$ Vdc, $V_{CE} = 20$ Vdc)	I_{CEX}	—	0.250	μAdc
Collector Cutoff Current ($V_{CB} = 40$ Vdc, $I_E = 0$) ($V_{CB} = 40$ Vdc, $I_E = 0$, $T_A = 150°C$)	I_{CBO}	— —	0.250 200	μAdc
Emitter Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	0.05	μAdc
Base Cutoff Current ($V_{BE} = 0.2$ Vdc, $V_{CE} = 20$ Vdc) ($V_{BE} = 0.2$ Vdc, $V_{CE} = 20$ Vdc, $T_A = 150°C$)	I_{BL}	— —	0.250 200	μAdc
ON CHARACTERISTICS(1)				
DC Forward Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) 2N2539 ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) 2N2539 ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)(1) 2N2539 ($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc)(1) 2N2539	h_{FE}	20 30 50 20	— — 150 —	—
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	8.0	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)	C_{ibo}	—	25	pF
Small-Signal Current Gain ($V_{CE} = 20$ Vdc, $I_C = 20$ mAdc, f = 100 MHz)	h_{fe}	2.5	—	—
SWITCHING CHARACTERISTICS				
Storage Time ($I_C = I_{B1} = I_{B2} = 20$ mAdc, $V_{CC} = 5.0$ V)	τ_S	—	20	ns
Active Region Time Constant	τ_A	—	2.0	ns
Turn-On Time ($I_{B1} = I_{B2} = 15$ mAdc, $I_C = 150$ mAdc, $V_{CC} = 7.0$ Vdc, $R_L = 40\ \Omega$)	t_{on}	—	40	ns
Turn-Off Time ($I_{B1} = I_{B2} = 15$ mAdc, $I_C = 150$ mAdc, $V_{CC} = 7.0$ Vdc, $R_L = 40\ \Omega$)	t_{off}	—	40	ns
Total Control Charge	Q_T	—	750	pC

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N2605

JAN, JTX AVAILABLE
CASE 26-03, STYLE 1
TO-46 (TO-206AB)

4

AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N3962 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	V
Collector-Base Voltage	V_{CBO}	60	V
Emitter-Base Voltage	V_{EBO}	6	V
Collector Current — Continuous	I_C	30	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.28	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) I_C = 10 mA (Pulse)	$V_{(BR)CEO}$	45	—	V
Collector-Base Breakdown Voltage (I_C = 10 μA)	$V_{(BR)CBO}$	60	—	V
Emitter-Base Breakdown Voltage (I_E = 10 μA)	$V_{(BR)EBO}$	6	—	V
Collector Cutoff Current (V_{CB} = 45 V)	I_{CBO}	—	10	nA
Base-Emitter Short Circuit Current (V_{CE} = 45 V) (V_{CE} = 45 V, T_A = 170°C)	I_{CES}	— —	10 10	nA μA
Emitter Cutoff Current (V_{BE} = 5.0 V)	I_{EBO}	—	2	nA
ON CHARACTERISTICS				
DC Current Gain(1) (V_{CE} = 5.0 V, I_C = 10 μA) (V_{CE} = 5.0 V, I_C = 500 μA) (V_{CE} = 5.0 V, I_C = 10 mA) (V_{CE} = 5.0 V, I_C = 10 μA, T_A = −55°C)	h_{FE}	100 150 — 20	300 — 600 —	— — — —
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_B = 500 μA)	$V_{CE(sat)}$	—	0.5	V
Base-Emitter Saturation Voltage (I_C = 10 mA, I_B = 500 μA)	$V_{BE(sat)}$	0.7	0.9	V
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 5.0 V, I_E = 0, f = 1.0 MHz)	C_{obo}	—	6	pF
Input Impedance (V_{CE} = 5.0 V, I_C = 1.0 mA, f = 100 MHz)	h_{ie}	—	200	Ω
Input Impedance (V_{CB} = 5.0 V, I_E = 1.0 mA, f = 1.0 kHz)	h_{ib}	25	35	Ω
Voltage Feedback Ratio (V_{CB} = 5.0 V, I_E = 1.0 mA, f = 1.0 kHz)	h_{rb}	—	10	10^{-4}
Small-Signal Current Gain (V_{CB} = 5.0 V, I_E = 1.0 mA, f = 1.0 kHz) (V_{CB} = 5.0 V, I_C = 500 μA, f = 30 MHz)	h_{fe}	150 1.0	600 —	— —
Output Admittance (V_{CB} = 5.0 V, I_E = 1.0 mA, f = 1.0 kHz)	h_{ob}	—	1	μmho
Noise Figure(2) (V_{CB} = 5.0 V, I_C = 10 μA, R_g = 10 k Ω, BW = 15.7 kHz)	NF	—	3	dB

(1) Pulse Width < 300 μsec, Duty Cycle ≤ 2.0%.
(2) Measured in amplifier with response down 3 db at 10 Hz.

2N2800

CASE 79, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTOR

PNP SILICON

Refer to 2N2904 for graphs.

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Collector-Base Voltage	V_{CBO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	800	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.8 4.57	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	3.0 17.14	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 100$ mAdc, $I_B = 0$)	$V_{CEO(sus)}$	35	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	50	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 25$ Vdc, $V_{BE} = 0.5$ Vdc Off)	I_{CEX}	—	100	nAdc
Base Cutoff Current ($V_{CE} = 25$ Vdc, $V_{BE} = 0.5$ Vdc Off)	I_{BL}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)(1) ($I_C = 150$ mAdc, $V_{CE} = 1.0$ Vdc)(1) ($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc)(1)	h_{FE}	 20 30 15 25	 — 90 — —	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)	$V_{CE(sat)}$	 — —	 0.4 1.2	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)	$V_{BE(sat)}$	 — —	 1.3 1.8	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	120	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, f = 100 kHz)	C_{obo}	—	25	pF
SWITCHING CHARACTERISTICS				
Delay Time	t_d	9	25	ns
Rise Time	t_r	25	45	ns
Storage Time	t_s	100	225	ns
Fall Time	t_f	30	45	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N2894

CASE 22, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

PNP SILICON

4

Refer to 2N869A for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage(1)	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	12	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	360 2.06	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1200 6.85	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

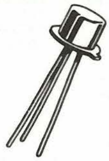
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 10\ \mu Adc$, $V_{BE} = 0$)	$V_{(BR)CES}$	12	—	Vdc
Collector-Emitter Sustaining Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{CEO(sus)}$	12	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu Adc$, $I_E = 0$)	$V_{(BR)CBO}$	12	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu Adc$, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 6.0$ Vdc, $I_E = 0$, $T_A = 125°C$)	I_{CBO}	—	10	μAdc
Collector Cutoff Current ($V_{CE} = 6.0$ Vdc, $V_{BE} = 0$)	I_{CES}	—	80	nAdc
Base Current ($V_{CE} = 6.0$ Vdc, $V_{BE} = 0$)	I_B	—	80	nAdc
ON CHARACTERISTICS				
DC Current Gain(2) ($I_C = 10$ mAdc, $V_{CE} = 0.3$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 0.5$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 0.5$ Vdc, $T_A = -55°C$) ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)(2)	h_{FE}	 30 40 17 25	 — 150 — —	—
Collector-Emitter Saturation Voltage(2) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc) ($I_C = 100$ mAdc, $I_B = 10$ mAdc)	$V_{CE(sat)}$	 — — —	 0.15 0.2 0.5	Vdc
Base-Emitter Saturation Voltage(2) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc) ($I_C = 100$ mAdc, $I_B = 10$ mAdc)	$V_{BE(sat)}$	 0.78 0.85 —	 0.98 1.2 1.7	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	400	—	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 140 kHz)	C_{obo}	—	6.0	pF
Input Capacitance ($V_{BE} = -0.5$ Vdc, $I_C = 0$, f = 140 kHz)	C_{ibo}	—	6.0	pF
SWITCHING CHARACTERISTICS				
Turn-On Time ($V_{CC} = 2.0$ Vdc, $V_{BE} = 3.0$ Vdc, $I_C = 30$ mAdc, $I_{B1} = 1.5$ mAdc)	t_{on}	—	60	ns
Turn-Off Time ($V_{CC} = 2.0$ Vdc, $I_C = 30$ mAdc, $I_{B1} = I_{B2} = 1.5$ mAdc)	t_{off}	—	90	ns

(1) Applicable from 0.01 to 10 mAdc.
(2) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.

2N2895
2N2896
2N2897

CASE 22, STYLE 1
TO-18 (TO-206AA)



GENERAL PURPOSE TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N2895	2N2896	2N2897	Unit
Collector-Emitter Voltage	V_{CEO}	65	90	45	Vdc
Collector-Emitter Voltage	V_{CER}	80	140	60	Vdc
Collector-Base Voltage	V_{CBO}	120	140	60	Vdc
Emitter-Base Voltage	V_{EBO}	7.0			Vdc
Collector Current — Continuous	I_C	1.0			Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 2.86			Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10.3			Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200			°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 100 mAdc, R_{BE} = 10 ohms)	2N2895 2N2896 2N2897	$V_{(BR)CER}$	80 140 60	— — —	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 100 mAdc, I_B = 0)	2N2895 2N2896 2N2897	$V_{CEO(sus)}$	65 90 45	— — —	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	2N2895 2N2896 2N2897	$V_{(BR)CBO}$	120 140 60	— — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)		$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_C = 0)	2N2895 2N2896 2N2897	I_{CBO}	— — —	0.002 0.01 0.05	μAdc
(V_{CB} = 60 Vdc, I_E = 0, T_A = +150°C)	2N2895 2N2897		— —	2.0 50	
(V_{CB} = 90 Vdc, I_E = 0)	2N2896		—	0.01	
(V_{CB} = 90 Vdc, I_E = 0, T_A = +150°C)	2N2896		—	10	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	2N2895 2N2896 2N2897	I_{EBO}	— — —	0.005 0.01 0.05	μAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 10 μAdc, V_{CE} = 10 Vdc)	2N2895		10	—	
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	2N2895		20	—	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N2896, 2N2897		35	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N2895		35	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = −55°C)	2N2895, 2N2896		20	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	2N2895 2N2896 2N2897		40 60 50	120 200 200	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	2N2895		25	—	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)	2N2895, 2N2896 2N2897	$V_{CE(sat)}$	— —	0.6 1.0	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)	2N2895, 2N2896 2N2897	$V_{BE(sat)}$	— —	1.2 1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	2N2895, 2N2896 2N2897	f_T	120 100	— —	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	80	pF
Small-Signal Current Gain (I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N2895 2N2896, 2N2897	h_{fe}	50 50	200 275	—
Noise Figure (I_C = 0.3 mAdc, V_{CE} = 10 Vdc, R_S = 500 ohms, f = 1.0 kHz, BW = 15 kHz)	2N2895	NF	—	8.0	dB

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.8%.

2N2904,A, 2N2905,A, 2N2906,A, 2N2907,A, 2N3485,A, 2N3486,A

JAN, JTX, JTXV AVAILABLE*

CASE 79-02, STYLE 1
2N2904/2905 TO-39 (TO-205AD)

CASE 22-03, STYLE 1
2N2906/2907 TO-18 (TO-206AA)

CASE 26-03, STYLE 1
2N3485/3486 TO-46 (TO-206AB)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Non-A Suffix		A-Suffix	Unit
Collector-Emitter Voltage	V_{CEO}	40		60	Vdc
Collector-Base Voltage	V_{CBO}	60			Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current — Continuous	I_C	600			mAdc
		2N2904,A 2N2905,A	2N2906,A 2N2907,A	2N3485,A 2N3486,A	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	600 3.43	400 2.28	400 2.28	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.0 17.2	1.8 10.3	2.0 11.43	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200			°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	Non-A Suffix A-Suffix	$V_{(BR)CEO}$	40 60	— —	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0.5 Vdc)		I_{CEX}	—	—	50	nAdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	Non-A Suffix A-Suffix	I_{CBO}	— —	— —	0.020 0.010	μAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)	Non-A Suffix A-Suffix		— —	— —	20 10	
Base Current (V_{CE} = 30 Vdc, V_{BE} = 0.5 Vdc)		I_B	—	—	50	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N2904, 2N2906, 2N3485 2N2905, 2N2907, 2N3486 2N2904A, 2N2906A, 2N3485A 2N2905A, 2N2907A, 2N3486A	h_{FE}	20 35 40 75	— — — —	— — — —	—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N2904, 2N2906, 2N3485 2N2905, 2N2907, 2N3486 2N2904A, 2N2906A, 2N3485A 2N2905A, 2N2907A, 2N3486A		25 50 40 100	— — — —	— — — —	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N2904, 2N2906, 2N3485 2N2905, 2N2907, 2N3486 2N2904A, 2N2906A, 2N3485A 2N2905A, 2N2907A, 2N3486A		35 75 40 100	— — — —	— — — —	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	2N2904A, 2N2906A, 2N3485,A 2N2905A, 2N2907A, 2N3486A		40 100	— —	120 300	

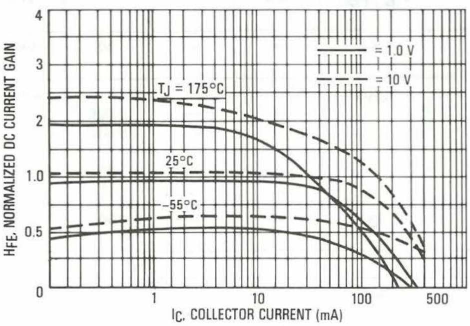
***ALSO AVAILABLE 2N2905ALJANS AND 2N2907AJANS**

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

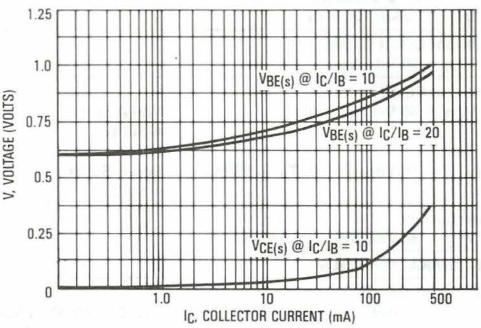
Characteristic		Symbol	Min	Typ	Max	Unit
(I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	2N2904, 2N2906, 2N3485		20	—	—	
	2N2905, 2N2907, 2N3486		30	—	—	
	2N2904A, 2N2906A, 2N3485A		40	—	—	
	2N2905A, 2N2907A, 2N3486A		50	—	—	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	—	0.4	
(I_C = 500 mAdc, I_B = 50 mAdc)			—	—	1.6	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)(1)			—	—	1.3	
(I_C = 500 mAdc, I_B = 50 mAdc)			—	—	2.6	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(2) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	—	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	—	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	—	30	pF
SWITCHING CHARACTERISTICS						
Turn-On Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_{on}	—	26	45	ns
Delay Time		t_d	—	6.0	10	ns
Rise Time		t_r	—	20	40	ns
Turn-Off Time	(V_{CC} = 6.0 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_{off}	—	70	100	ns
Storage Time		t_s	—	50	80	ns
Fall Time		t_f	—	20	30	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0.%
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

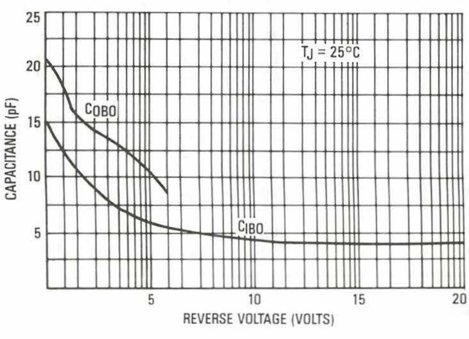
NORMALIZED DC CURRENT GAIN



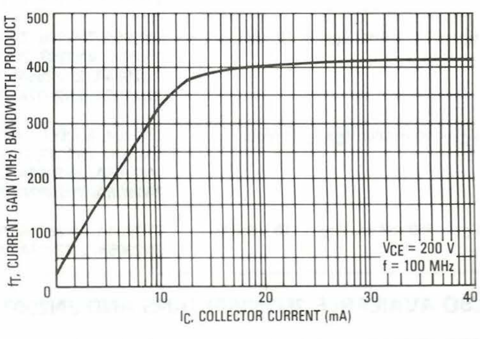
"ON" VOLTAGE



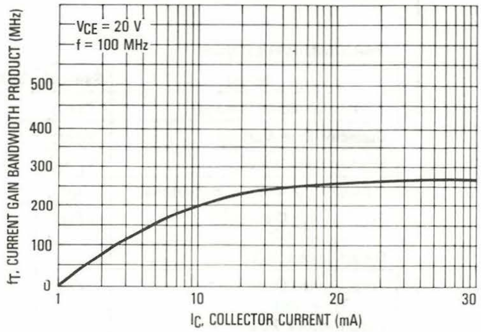
CAPACITANCE



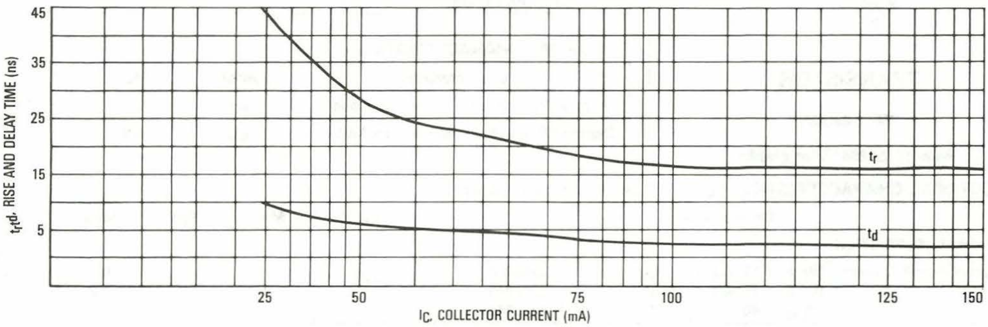
CURRENT GAIN—BANDWIDTH PRODUCT



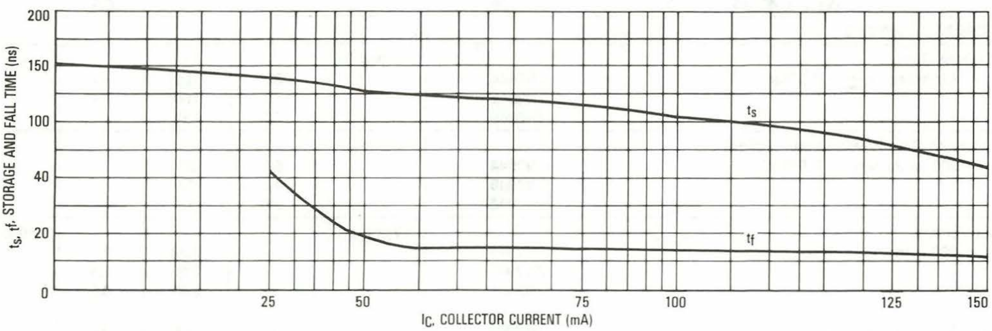
CURRENT GAIN — BANDWIDTH PRODUCT



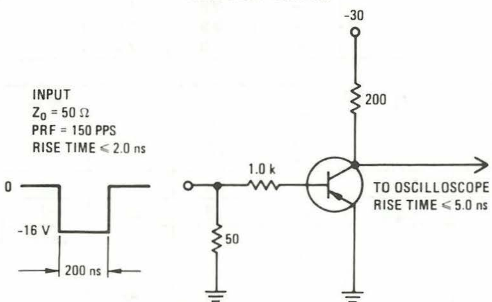
TURN ON BEHAVIOR



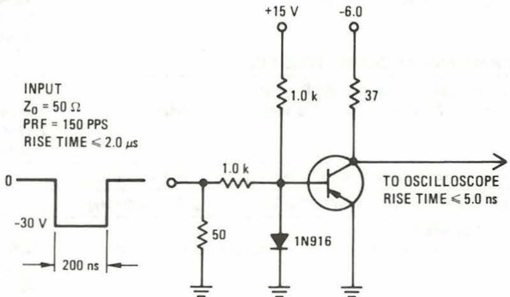
TURN OFF BEHAVIOR



DELAY AND RISE TIME TEST CIRCUIT



STORAGE AND FALL TIME TEST CIRCUIT



2N2944 thru 2N2946

CASE 26-03, STYLE 1
TO-46 (TO-206AB)

TRANSISTOR

PNP SILICON

Refer to 2N2944A for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N2944	2N2945	2N2946	Unit
Emitter-Collector Voltage	V_{ECO}	10	20	35	Vdc
Collector-Base Voltage	V_{CBO}	15	25	40	Vdc
Emitter-Base Voltage	V_{EBO}	15	25	40	Vdc
Collector Current — Continuous	I_C	100			mAdc
Total Device Dissipation @ T_A = 25°C	P_D	400			mW
Derate above 25°C		2.3			mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	2.0			Watts
Derate above 25°C		11.43			mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	87.5	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	435	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	2N2944	I_{CBO}	—	—	0.1	nAdc
(V_{CB} = 25 Vdc, I_E = 0)	2N2945		—	—	0.2	
(V_{CB} = 40 Vdc, I_E = 0)	2N2946		—	—	0.5	
Emitter Cutoff Current (V_{EB} = 15 Vdc, I_C = 0)	2N2944	I_{EBO}	—	—	0.1	nAdc
(V_{EB} = 25 Vdc, I_C = 0)	2N2945		—	—	0.2	
(V_{EB} = 40 Vdc, I_C = 0)	2N2946		—	—	0.5	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				—
(I_C = 1.0 mAdc, V_{CE} = 0.5 Vdc)	2N2944		80	180	—	
	2N2945		40	160	—	
	2N2946		30	130	—	
*DC Current Gain (inverted connection)		$h_{FE(inv)}$				—
(I_B = 200 μAdc, V_{EC} = 0.5 Vdc)	2N2944		6.0	20	—	
	2N2945		4.0	17	—	
	2N2946		3.0	15	—	
Offset Voltage		$V_{EC(ofs)}$				mVdc
(I_B = 200 μAdc, I_E = 0)	2N2944		—	0.18	0.3	
	2N2945		—	0.23	0.5	
	2N2946		—	0.27	0.8	
(I_B = 1.0 mAdc, I_E = 0)	2N2944		—	0.4	0.6	
	2N2945		—	0.5	1.0	
	2N2946		—	0.6	2.0	
(I_B = 2.0 mAdc, I_E = 0)	2N2944		—	0.8	1.0	
	2N2945		—	0.9	1.6	
	2N2946		—	1.0	2.5	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product		f_T				MHz
(I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 MHz)	2N2944		10	15	—	
	2N2945		5.0	13	—	
	2N2946		3.0	12	—	
Output Capacitance (V_{CB} = 6.0 Vdc, I_E = 0, f = 500 kHz)		C_{obo}	—	3.2	10	pF
Input Capacitance (V_{EB} = 6.0 Vdc, I_C = 0, f = 500 kHz)		C_{ibo}	—	1.9	6.0	pF
"ON" Series Resistance		r_{ec}				Ohms
(I_B = 1.0 mAdc, I_E = 0, I_c = 100 μArms, f = 1.0 kHz)	2N2944		—	4.0	20	
	2N2945		—	4.5	35	
	2N2946		—	5.0	45	

*Indicates Data in addition to JEDEC Requirements.

MAXIMUM RATINGS

Rating	Symbol	2N2944A	2N2945A	2N2946A	Unit
Emitter-Collector Voltage	V_{ECO}	10	20	35	Vdc
Collector-Base Voltage	V_{CBO}	15	25	40	Vdc
Emitter-Base Voltage	V_{EBO}	15	25	40	Vdc
Collector Current — Continuous	I_C	100			mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	400 2.3			mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.0 11.43			Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200			°C
Lead Temperature 1/16″ from Case for 10 seconds	T_L	240			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	435	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	87.5	°C/W

2N2944A
2N2945A
2N2946A

JAN, JTX, JTXV AVAILABLE
CASE 26-03, STYLE 1
TO-46 (TO-205AB)

CHOPPER TRANSISTOR

PNP SILICON

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Emitter-Collector Breakdown Voltage ($I_E = 10\ \mu Adc$, $I_B = 0$)	2N2944A	$V_{(BR)ECO}$	10	—	—	Vdc
	2N2945A		20	—	—	
	2N2946A		35	—	—	
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	2N2944A	I_{CBO}	—	—	0.1	nAdc
($V_{CB} = 25$ Vdc, $I_E = 0$)	2N2945A		—	—	0.2	
($V_{CB} = 40$ Vdc, $I_E = 0$)	2N2946A		—	—	0.5	
($V_{CB} = 15$ Vdc, $I_E = 0$, $T_A = 100°C$)	2N2944A		—	—	10	
($V_{CB} = 25$ Vdc, $I_E = 0$, $T_A = 100°C$)	2N2945A		—	—	20	
($V_{CB} = 40$ Vdc, $I_E = 0$, $T_A = 100°C$)	2N2946A		—	—	25	
Emitter Cutoff Current ($V_{EB} = 25$ Vdc, $I_C = 0$)	2N2944A	I_{EBO}	—	—	0.1	nAdc
	2N2945A		—	—	0.2	
($V_{EB} = 40$ Vdc, $I_C = 0$)	2N2946A		—	—	0.5	
($V_{EB} = 25$ Vdc, $I_C = 0$, $T_A = 100°C$)	2N2944A		—	—	10	
	2N2945A		—	—	15	
($V_{EB} = 40$ Vdc, $I_C = 0$, $T_A = 100°C$)	2N2946A		—	—	20	
ON CHARACTERISTICS						
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 0.5$ Vdc)	2N2944A	h_{FE}	100	—	—	—
	2N2945A		70	200	—	
	2N2946A		50	200	—	
DC Current Gain (Inverted Connection) ($I_B = 200\ \mu Adc$, $V_{EC} = 0.5$ Vdc)	2N2944A	$h_{FE(inv)}$	50	—	—	—
	2N2945A		30	32	—	
	2N2946A		20	25	—	
Offset Voltage ($I_B = 200\ \mu Adc$, $I_E = 0$)	2N2944A	$V_{EC(ofs)}$	—	0.23	0.3	mVdc
	2N2945A		—	0.4	0.5	
	2N2946A		—	0.7	0.8	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
(I_B = 1.0 mAdc, I_E = 0)	2N2944A		—	—	0.6	
	2N2945A		—	0.5	1.0	
	2N2946A		—	0.6	2.0	
(I_B = 2.0 mAdc, I_E = 0)	2N2944A		—	—	1.0	
	2N2945A		—	0.9	1.6	
	2N2946A		—	1.0	2.5	

SMALL-SIGNAL CHARACTERISTICS

Characteristic		Symbol	Min	Typ	Max	Unit
Current-Gain — Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 MHz)		f_T				MHz
	2N2944A		—	—	—	
	2N2945A		10	15	—	
	2N2946A		5.0	8.0	—	
Output Capacitance (V_{CB} = 6.0 Vdc, I_E = 0, f = 0.1 MHz to 1.0 MHz)		C_{obo}	—	3.2	10	pF
Input Capacitance (V_{EB} = 6.0 Vdc, I_C = 0, f = 0.1 MHz to 1.0 MHz)		C_{ibo}	—	1.9	6.0	pF
"ON" Series Resistance (I_B = 1.0 mAdc, I_E = 0, I_e = 100 μArms, f = 1.0 kHz)		$r_{ec(on)}$				Ohms
	2N2944A		—	—	4.0	
	2N2945A		—	5.0	6.0	
	2N2946A		—	7.0	8.0	

FIGURE 1 — $V_{EC(on)}$

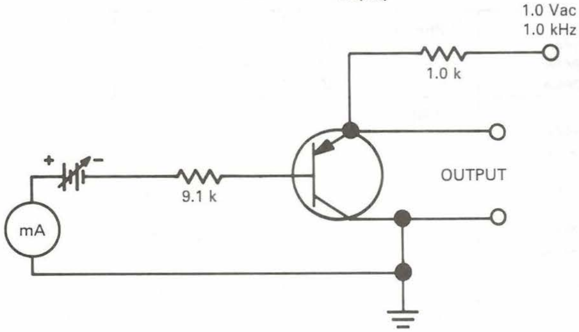
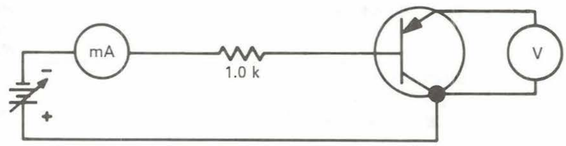


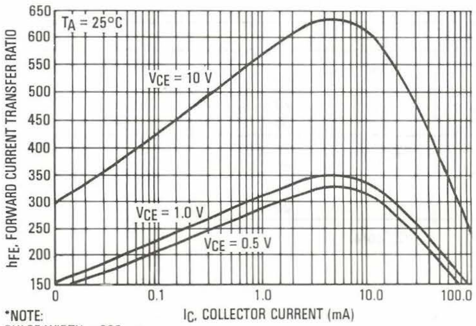
FIGURE 2 — $V_{EC(offset)}$



mA + + + + + - - - - - 9.1 k 2% 1.0 Vac
10 k 2% Output Figure 1 — rec(on) $r_{ec(on)}$ $r_{ec(on)}$
mA 1.0k 2% V

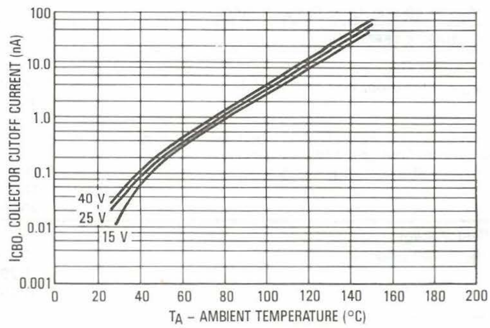
Output measured with H.P. 400D
Ac VTVM or equivalent.
1.0 mV = 1.0 Ω rec(on)

h_{FE} versus I_C

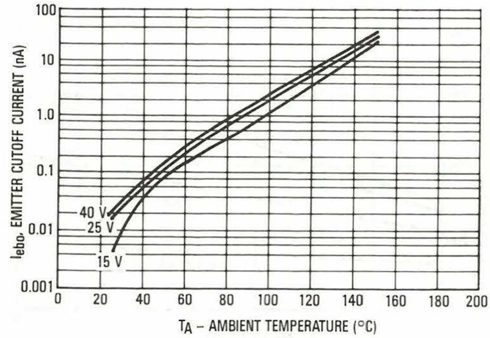


*NOTE:
PULSE WIDTH = 300 μs,
DUTY CYCLE ≤ 2%

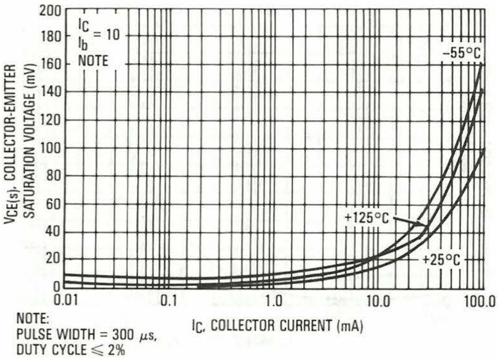
I_{CBO} versus T_A



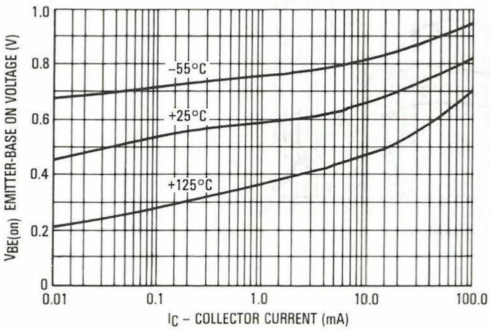
I_{ebo} versus T_A



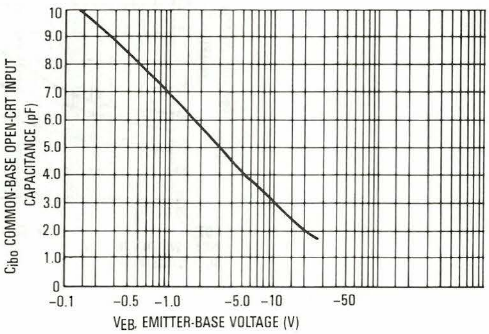
$V_{CE(s)}$ versus I_C



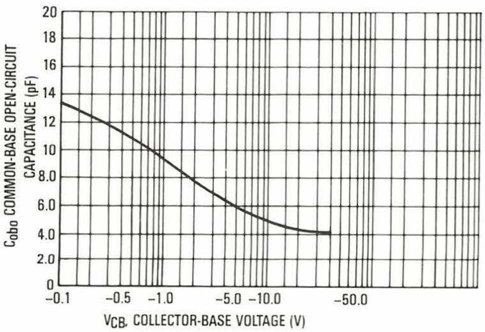
$V_{BE(on)}$ versus I_C



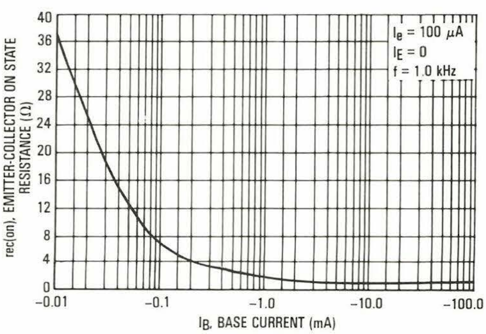
C_{ibo} versus V_{EB}



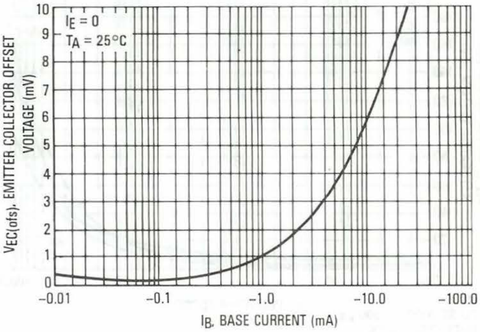
C_{obo} versus V_{CB}



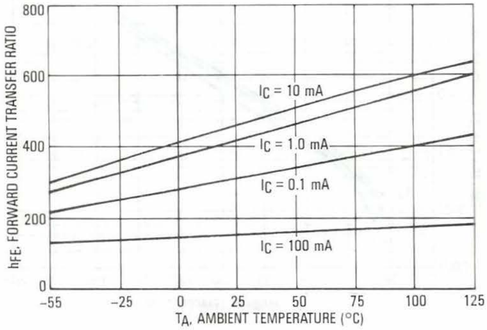
rec(on) versus I_B



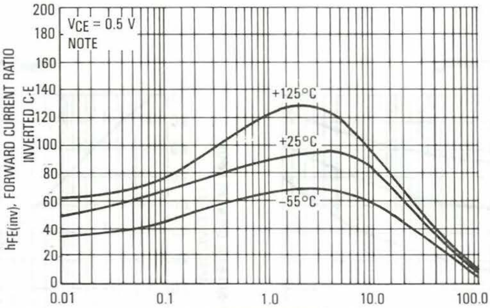
$V_{EC(ofs)}$ versus I_B



h_{FE} versus T_A



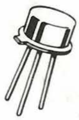
$h_{FE(inv)}$, versus I_C



NOTE:
PULSE WIDTH = 300 μs,
DUTY CYCLE ≤ 2%

2N2959

CASE 79, STYLE 1
TO-39 (TO-205AD)



SWITCHING TRANSISTORS

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	600	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	3.0 20	Watts mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	0.6 4.00	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

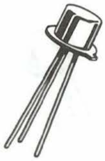
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, pulsed, I_B = 0)	$V_{(BR)CEO}$	20	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0.5 Vdc)	I_{CEX}	—	.050	μAdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 — —	 0.025 15	μAdc
Base Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0.5 Vdc)	I_{BL}	—	.050	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 150 mAdc, V_{CE} = 10 Vdc)	h_{FE}	100	300	—
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	—	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 20 mA, V_{CE} = 20 V, f = 100 MHz)	f_T	250	—	MHz
Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 100 kHz)	C_{obo}	—	8.0	pF
SWITCHING CHARACTERISTICS				
Delay Time (V_{CC} = 30 V, I_{CS} = 150 mA, I_{B1} = 15 mA)	t_d	—	20	ns
Rise Time (V_{CC} = 30 V, I_{CS} = 150 mA, I_{B1} = 15 mA)	t_r	—	75	ns
Storage Time (V_{CC} = 6.0 V, I_{CS} = 150 mA, I_{B1} = 15 mA, I_{B2} = 15 mA)	t_s	—	300	ns
Fall Time (V_{CC} = 6.0 V, I_{CS} = 150 mA, I_{B1} = 15 mA, I_{B2} = 15 mA)	t_f	—	200	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N3011

CASE 22, STYLE 1
TO-18 (TO-206AA)



4

SWITCHING TRANSISTOR

NPN SILICON

Refer to 2N2368 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage(1)	V_{CEO}	12	Vdc
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous Peak (10 μs Pulse)	I_C	200 500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ T_C = 25°C T_C = 100°C Derate above 25°C	P_D	1.20 0.68 6.85	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	12	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	$V_{(BR)CES}$	30	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc V_{BE} = 0) (V_{CE} = 20 Vdc, V_{BE} = 0, T_A = +85°C)	I_{CES}	— —	0.4 10	μAdc
Base Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 0)	I_{BL}	—	0.4	μAdc
ON CHARACTERISTICS (2)				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 0.35 Vdc) (I_C = 30 mAdc, V_{CE} = 0.4 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	30 25 12	120 — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 30 mAdc, I_B = 3.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = +85°C)	$V_{CE(sat)}$	— — — —	0.20 0.25 0.50 0.30	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 30 mAdc, I_B = 3.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	0.72 — —	0.87 1.15 1.60	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{obo}	—	4.0	pF
SWITCHING CHARACTERISTICS				
Storage Time (I_C = I_{B1} = $-I_{B2}$ = 10 mAdc)	t_s	—	13	ns
Turn-On Time (V_{CC} = 2.0 Vdc, $V_{EB(off)}$ = 0, I_C = 30 mAdc, I_{B1} = 3.0 mAdc)	t_{on}	—	15	ns
Turn-Off Time (V_{CC} = 2.0 Vdc, I_C = 30 mAdc, I_{B1} = $-I_{B2}$ = 3.0 mAdc)	t_{off}	—	20	ns

(1) Applicable from 0.01 mA to 10 mA (Pulsed).
(2) Pulse Test: Pulse Length = 30 μs, Duty Cycle ≤ 2.0%.

2N3012

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

PNP SILICON

4

Refer to 2N869A for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	12	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.36 2.06	Watts mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.2 6.85	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 10\ \mu Adc$, $V_{BE} = 0$)	$V_{(BR)CES}$	12	—	Vdc
Collector-Emitter Sustaining Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$) (Emitter-Base Termination — Open Base)	$V_{CEO(sus)}$	12	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu Adc$, $I_E = 0$)	$V_{(BR)CBO}$	12	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu Adc$, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 6.0$ Vdc, $V_{BE} = 0$) ($V_{CE} = 6.0$ Vdc, $V_{BE} = 0$, $T_A = +85°C$)	I_{CES}	— —	80 5.0	μAdc
Base Current ($V_{CE} = 6.0$ Vdc, $V_{BE} = 0$)	I_B	—	30	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 0.3$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 0.5$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)(1)	h_{FE}	 25 30 20	 — 120 —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc) ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc, $T_A = +85°C$) ($I_C = 100$ mAdc, $I_B = 10$ mAdc)	$V_{CE(sat)}$	 — — — —	 0.15 0.2 0.4 0.5	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc) ($I_C = 100$ mAdc, $I_B = 10$ mAdc)	$V_{BE(sat)}$	 0.78 0.85 —	 0.98 1.2 1.7	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 140 kHz)	C_{obo}	—	6.0	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 140 kHz)	C_{ibo}	—	6.0	pF
Small-Signal Current Gain ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	h_{fe}	4.0	—	—
SWITCHING CHARACTERISTICS				
Turn-On Time ($V_{CC} = 2.0$ Vdc, $I_C \approx 30$ mAdc, $I_{B1} \approx 1.5$ mAdc)	t_{on}	—	60	ns
Turn-Off Time ($V_{CC} = 2.0$ Vdc, $I_C \approx 30$ mAdc, $I_{B1} = I_{B2} \approx 1.5$ mAdc)	t_{off}	—	75	ns

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 1.0%.

2N3013
2N3014

2N3013 JAN, JTX AVAILABLE
CASE 27, STYLE 1
TO-52 (TO-206AC)

SWITCHING TRANSISTOR

NPN SILICON

Refer to 2N3510 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage(1) 2N3013 / 2N3014	V_{CEO}	15 / 20	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous / (10 μs pulse) Peak	I_C	200 / 500	mAdc
Total Device Dissipation @ $T_A = 25°C$ / Derate above 25°C	P_D	0.36 / 2.06	Watt / mW/°C
Total Device Dissipation @ $T_C = 25°C$ / @ $T_C = 100°C$ / Derate above 25°C	P_D	1.20 / 0.68 / 6.85	Watts / Watt / mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

(1) Applicable from 0.01 mA to 10 mA (Pulsed)

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu Adc$, $V_{BE} = 0$)		$V_{(BR)CES}$	40	—	Vdc
Collector-Emitter Sustaining Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)	2N3013	$V_{CEO(sus)}$	15	—	Vdc
	2N3014		20	—	
Collector-Base Breakdown Voltage ($I_C = 100\ \mu Adc$, $I_E = 0$)		$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu Adc$, $I_C = 0$)		$V_{(BR)EBO}$	5.0	— —	Vdc
Collector Cutoff Current		I_{CES}			μAdc
($V_{CE} = 20$ Vdc, $V_{BE} = 0$)			—	0.3	
($V_{CE} = 20$ Vdc, $V_{BE} = 0$, $T_A = +125°C$)			—	40	
Base Current ($V_{CE} = 20$ Vdc, $V_{BE} = 0$)		I_B	—	0.3	μAdc
ON CHARACTERISTICS(2)					
DC Current Gain		h_{FE}			—
($I_C = 30$ mAdc, $V_{CE} = 0.4$ Vdc)			30	120	
($I_C = 100$ mAdc, $V_{CE} = 0.5$ Vdc)	2N3013		25	—	
($I_C = 10$ mAdc, $V_{CE} = 0.4$ Vdc)	2N3014		25	—	
($I_C = 300$ mAdc, $V_{CE} = 1.0$ Vdc)	2N3013		15	—	
($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)	2N3014		25	—	
($I_C = 30$ mAdc, $V_{CE} = 0.4$ Vdc, $T_A = -55°C$)			12	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
($I_C = 30$ mAdc, $I_B = 3.0$ mAdc)			—	0.18	
($I_C = 100$ mAdc, $I_B = 10$ mAdc)	2N3013		—	0.28	
($I_C = 100$ mAdc, $I_B = 10$ mAdc)	2N3014		—	0.35	
($I_C = 300$ mAdc, $I_B = 30$ mAdc)	2N3013		—	0.50	
($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	2N3014		—	0.18	
($I_C = 30$ mAdc, $I_B = 3.0$ mAdc, $T_A = +125°C$)			—	0.25	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
($I_C = 30$ mAdc, $I_B = 3.0$ mAdc)			0.75	0.95	
($I_C = 100$ mAdc, $I_B = 10$ mAdc)			—	1.20	
($I_C = 300$ mAdc, $I_B = 30$ mAdc)	2N3013		—	1.70	
($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	2N3014		0.70	0.80	

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 30 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	350	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{obo}	—	5.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ibo}	—	8.0	pF
SWITCHING CHARACTERISTICS				
Storage Time (I_C = I_{B1} = I_{B2} = 10 mAdc)	t_s	—	18	ns
Turn-On Time	t_{on}			ns
($V_{EB(off)}$ = 5.0 V, V_{CC} = 15 V, I_C = 300 mAdc, I_{B1} = 30 mAdc) 2N3013		—	15	
($V_{EB(off)}$ = 0, V_{CC} = 2.0 V, I_C = 30 mAdc, I_{B1} = 3.0 mAdc) 2N3014		—	16	
Turn-Off Time	t_{off}			ns
(V_{CC} = 15 V, I_C = 300 mAdc, I_{B1} = I_{B2} = 30 mAdc) 2N3013		—	25	
(V_{CC} = 2.0 V, I_C = 30 mAdc, I_{B1} = I_{B2} = 3.0 mAdc) 2N3014		—	25	

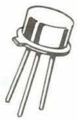
(2) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.

4

4

2N3019
2N3020
2N3700

JAN, JTX, JTXV AVAILABLE
2N3019, 2N3020
CASE 22 STYLE 1
TO-18 (TO-206AA)



GENERAL TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N3019 2N3020	2N3700	Unit
Collector-Emitter Voltage	V_{CEO}	80	80	Vdc
Collector-Base Voltage	V_{CBO}	140	140	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	7.0	Vdc
Collector Current — Continuous	I_C	1.0	1.0	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.8 4.6	0.5 2.85	Watts mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6	1.8 10.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N3019 2N3020	2N3700	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	16.5	70	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	89.5	245	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 30$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	80	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ µAdc, $I_E = 0$)		$V_{(BR)CBO}$	140	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ µAdc, $I_C = 0$)		$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 90$ Vdc, $I_E = 0$) ($V_{CB} = 90$ Vdc, $I_E = 0$, $T_A = +150°C$)		I_{CBO}	 — —	 0.01 10	µAdc
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$)		I_{EBO}	—	0.010	µAdc
ON CHARACTERISTICS					
DC Current Gain(1)		h_{FE}			—
($I_C = 0.1$ mAdc, $V_{CE} = 10$ Vdc)	2N3700, 2N3019 2N3020		50 30	— 100	
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	2N3700, 2N3019 2N3020		90 40	— 120	
($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)	2N3700, 2N3019 2N3020		100 40	300 120	
($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc, $T_C = -55°C$)	2N3700, 2N3019		40	—	
($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc)	2N3700, 2N3019 2N3020		50 30	— 100	
($I_C = 1.0$ Adc, $V_{CE} = 10$ Vdc)	All Types		15	—	
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)		$V_{CE(sat)}$	 — —	 0.2 0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)		$V_{BE(sat)}$	—	1.1	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)	 2N3020 2N3019, 2N3700	f_T	 80 100	 — 400	MHz

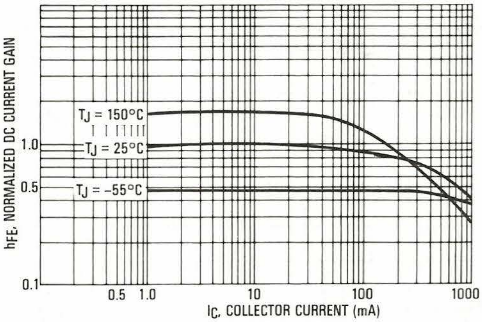
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	12	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	60	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N3700, 2N3019 2N3020	h_{fe}	80 30	400 200	—
Collector Base Time Constant (I_E = 10 mAdc, V_{CB} = 10 Vdc, f = 4.0 MHz)	2N3019, 2N3020 2N3700	$r_b'C_c$	— 15	400 400	ps
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 k ohms, f = 1.0 kHz)	2N3019, 2N3700	NF	—	4	dB

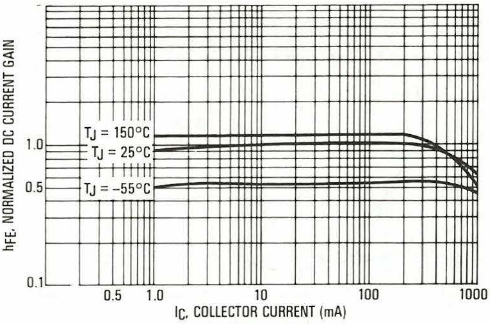
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

4

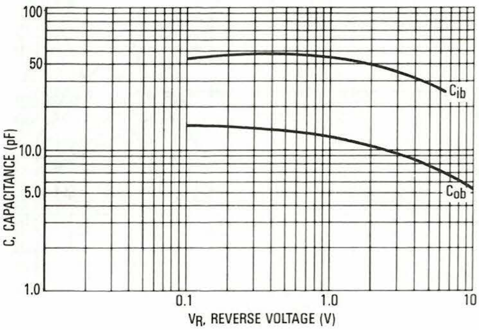
DC CURRENT GAIN
2N3019, 2N3700



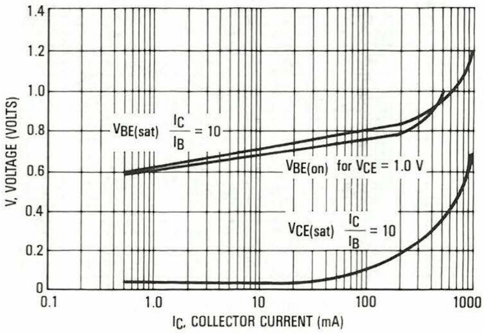
DC CURRENT GAIN
2N3020



CAPACITANCE

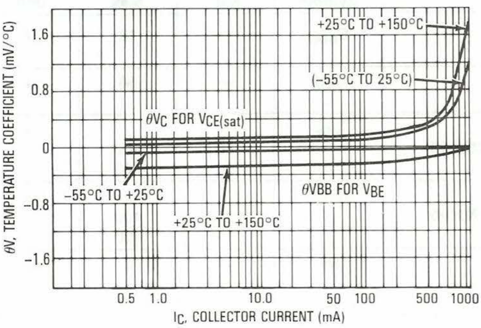


"ON" VOLTAGES

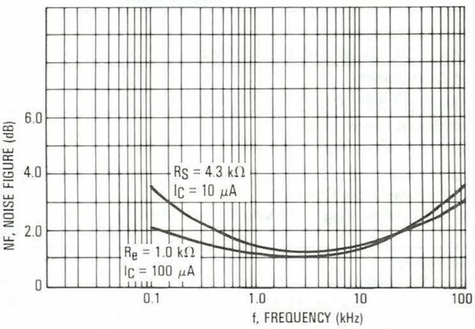


4

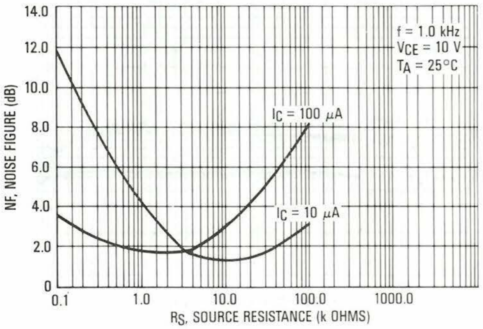
TEMPERATURE COEFFICIENTS



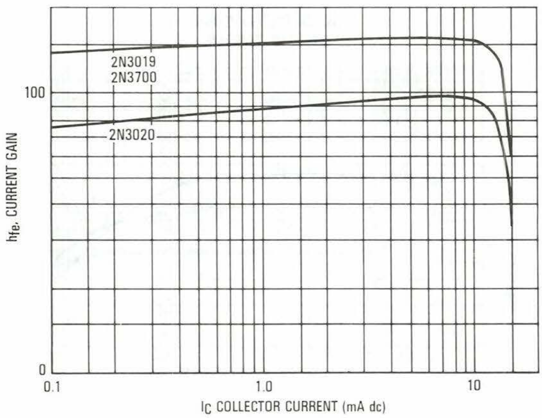
FREQUENCY EFFECTS



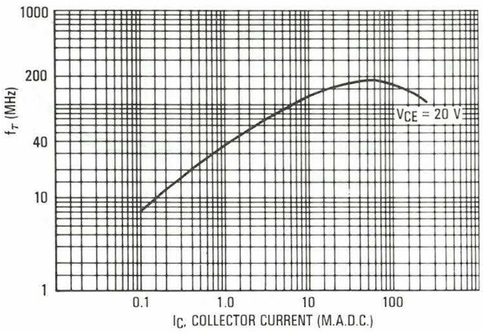
SOURCE RESISTANCE EFFECTS



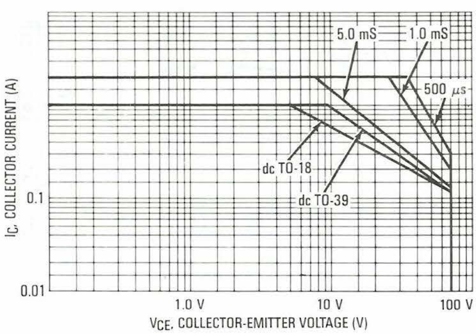
CURRENT GAIN BANDWIDTH PRODUCT versus COLLECTOR CURRENT — 1 kHz h_{fe}



CURRENT GAIN — BANDWIDTH PRODUCT



ACTIVE REGION SAFE OPERATING AREA



2N3053,A

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N3019 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N3053	2N3053A	Unit
Collector-Emitter Voltage(1)	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	700		mAdc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C
Lead Temperature 1/16″, ±1/32″ From Case for 10 s	T_L	+235		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W

(1) Applicable 0 to 100 mA (Pulsed):
Pulse Width ≤ 300 μsec., Duty Cycle ≤ 2.0%.
0 to 700 mA; Pulse Width ≤ 10 μsec., Duty Cycle ≤ 2.0%.

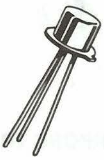
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 100\ \mu Adc$, $I_B = 0$)	 2N3053 2N3053A	$V_{(BR)CEO}$	 40 60	 — —	Vdc
Collector-Emitter Breakdown Voltage(2) ($I_C = 100$ mAdc, $R_{BE} = 10$ ohms)	 2N3053 2N3053A	$V_{(BR)CER}$	 50 70	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu Adc$, $I_E = 0$)	 2N3053 2N3053A	$V_{(BR)CBO}$	 60 80	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu Adc$, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 30$ Vdc, $V_{BE(off)} = 1.5$ Vdc) ($V_{CE} = 60$ Vdc, $V_{BE(off)} = 1.5$ Vdc)	 2N3053 2N3053A	I_{CEX}	—	0.25	μAdc
Emitter Cutoff Current ($V_{BE} = 4.0$ Vdc, $I_C = 0$)	 2N3053	I_{EBO}	—	0.25	μAdc
Base Cutoff Current ($V_{CE} = 60$ Vdc, $V_{BE(off)} = 1.5$ Vdc)	 2N3053A	I_{BL}	—	0.25	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 150$ mAdc, $V_{CE} = 2.5$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)		h_{FE}	25 50	— 250	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	 2N3053 2N3053A	$V_{CE(sat)}$	 — —	 1.4 0.3	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	 2N3053 2N3053A	$V_{BE(sat)}$	 — 0.6	 1.7 1.0	Vdc
Base-Emitter On Voltage ($I_C = 150$ mAdc, $V_{CE} = 2.5$ Vdc)	 2N3053 2N3053A	$V_{BE(on)}$	 — —	 1.7 1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)		f_T	100	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 140 kHz)		C_{obo}	—	15	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 140 kHz)		C_{ibo}	—	80	pF

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N3073

2N3073
CASE 22-03, STYLE 1
TO-18 (TO-206AA)



4

SWITCHING TRANSISTOR

PNP SILICON

Refer to 2N2904 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	360 2.06	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.2 6.85	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

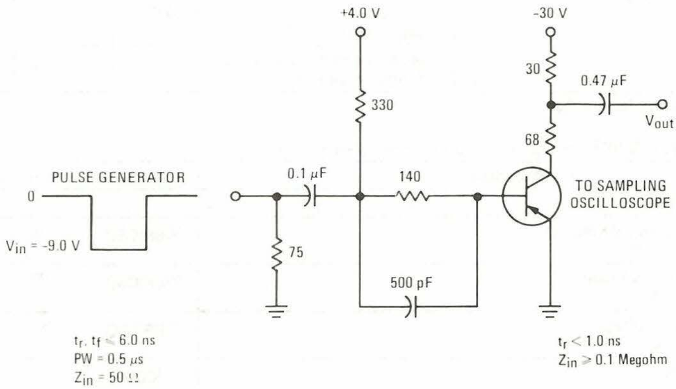
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 30$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	60	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 30$ Vdc, $V_{BE} = 0$) ($V_{CE} = 30$ Vdc, $V_{BE} = 0$, $T_A = 125°C$)	I_{CES}	— —	10 10	nAdc μAdc
Emitter Cutoff Current ($V_{EB} = 4.0$ Vdc, $I_C = 0$)	I_{EBO}	—	100	μAdc
Base Current ($V_{CE} = 30$ Vdc, $V_{BE} = 0$)	I_B	—	10	nAdc
ON CHARACTERISTICS				
DC Current Gain(1) ($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc, $T_A = -55°C$) ($I_C = 300$ mAdc, $V_{CE} = 2.0$ Vdc)	h_{FE}	30 12 15	130 — —	—
Collector-Emitter Saturation Voltage ($I_C = 50$ mAdc, $I_B = 2.5$ mAdc) ($I_C = 300$ mAdc, $I_B = 30$ mAdc)	$V_{CE(sat)}$	— —	0.25 1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 50$ mAdc, $I_B = 2.5$ mAdc) ($I_C = 300$ mAdc, $I_B = 30$ mAdc)	$V_{BE(sat)}$	— —	1.2 2.0	Vdc
Base-Emitter On Voltage ($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc)	$V_{BE(on)}$	—	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(2) ($I_C = 50$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	130	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 140 kHz)	C_{obo}	—	10	pF
Input Impedance ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{ie}	—	1.5	kohms
Voltage Feedback Ratio ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{re}	—	26	$X\ 10^{-4}$
Small Signal Current Gain ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{fe}	25	180	—
Output Admittance ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{oe}	—	1200	μmhos

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS				
Turn-On Time ($I_C \approx 300$ mAdc, $I_{B1} \approx 30$ mAdc)	t_{on}	—	40	ns
Turn-Off Time ($I_C \approx 300$ mAdc, $I_{B1} \approx I_{B2} \approx 30$ mAdc)	t_{off}	—	100	ns

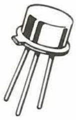
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 — TURN-ON AND TURN-OFF SWITCHING TIMES TEST CIRCUIT



2N3114

CASE 79, STYLE 1
TO-39 (TO-205AD)



AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N3498 for graphs.

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage(1)	V_{CEO}	150	Vdc
Collector-Base Voltage	V_{CBO}	150	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.8 4.57	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(2) (I_C = = 30 mAdc, $I_B = 0$)	$V_{(BR)CEO}$	150	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu Adc$, $I_E = 0$)	$V_{(BR)CBO}$	150	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu Adc$, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 100$ Vdc, $I_E = 0$) ($V_{CB} = 100$ Vdc, $I_E = 0$, $T_A = 150°C$)	I_{CBO}	 — —	 0.010 10	μAdc
Emitter Cutoff Current ($V_{EB} = 4.0$ Vdc, $I_C = 0$)	I_{EBO}	—	0.10	μAdc
ON CHARACTERISTICS				
DC Current Gain(2) ($I_C = 0.1$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc, $T_A = -55°C$)	h_{FE}	 15 30 12	 — 120 —	—
Collector-Emitter Saturation Voltage(2) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage(2) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 140 kHz)	C_{obo}	—	9.0	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 140 kHz)	C_{ibo}	—	80	pF
Small-Signal Current Gain ($I_C = 1.0$ mA, $V_{CE} = 5.0$ V, f = 1 kHz)	h_{fe}	25	—	—
Current Gain — High Frequency ($V_{CE} = 10$ Vdc, $I_C = 30$ mAdc, f = 20 MHz)	$\|h_{fe}\|$	2.0	—	—
Real Part of Input Impedance ($I_C = 10$ mA, $V_{CE} = 10$ V, f = 100 MHz)	$Re(h_{ie})$	—	30	Ohms

(1) Between 0 and 30 mA.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

2N3133

CASE 79, STYLE 1
TO-39 (TO-205AD)

2N3135

CASE 22, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

PNP SILICON

Refer to 2N2904 for graphs.

4

MAXIMUM RATINGS

Rating	Symbol	2N3133	2N3135	Unit
Collector-Emitter Voltage	V_{CEO}	35	35	Vdc
Collector-Base Voltage	V_{CBO}	50	50	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	4.0	Vdc
Collector Current — Continuous	I_C	600	600	mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.6 3.43	0.4 2.28	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	3 17.14	1.8 10.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

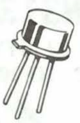
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	35	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	50	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 30$ V, $V_{BE} = 0.5$ V)	I_{CEX}	—	0.1	μAdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$) ($V_{CB} = 30$ Vdc, $I_E = 0$, $T_A = 150°C$)	I_{CBO}	 — —	 0.05 30	μAdc
Base Cutoff Current ($V_{CE} = 30$ V, $V_{BE} = 0.5$ V)	I_{BL}	—	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)(1)	h_{FE}	 25 40	 — 120	—
Collector-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{CE(sat)}$	—	0.6	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{BE(sat)}$	—	1.5	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	200	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	10	pF
Input Capacitance ($V_{BE} = 2$ Vdc, $I_C = 0$, f = 100 kHz)	C_{ibo}	—	40	pF
SWITCHING CHARACTERISTICS				
Turn-On Time ($V_{CC} = 30$ V, $I_C = 150$ mA, $I_{B1} = 15$ mA)	t_{on}	26	75	ns
Turn-Off Time ($V_{CC} = 6.0$ V, $I_C = 150$ mA, $I_{B1} = I_{B2} = 15$ mA)	t_{off}	70	150	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N3244
2N3245

CASE 79, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTOR

PNP SILICON

2N3227 For Specifications, See 2N2368 Data.

MAXIMUM RATINGS

Rating	Symbol	2N3244	2N3245	Unit
Collector-Emitter Voltage	V_{CEO}	40	50	Vdc
Collector-Base Voltage	V_{CBO}	40	50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.175	°C/mW

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	 2N3244 2N3245	$V_{(BR)CEO}$	 40 50	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	 2N3244 2N3245	$V_{(BR)CBO}$	 40 50	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Base Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 3.0 Vdc)		I_{BEV}	—	80	nAdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 3.0 Vdc)		I_{CEX}	—	50	nAdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 100°C)		I_{CBO}	 — —	 0.050 10	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0) (V_{EB} = 4.0 Vdc, I_C = 0)	 2N3245 2N3244	I_{EBO}	 — —	 30 30	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 150 mAdc, V_{CE} = 1.0 Vdc)	 2N3244 2N3245	h_{FE}	 60 35	 — —	—
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	2N3244 2N3245		50 30	150 90	
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	2N3244 2N3245		25 20	— —	
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)	 2N3244 2N3245	$V_{CE(sat)}$	 — —	 0.3 0.35	Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)	2N3244 2N3245		— —	0.5 0.6	
(I_C = 1.0 Adc, I_B = 100 mAdc)	2N3244 2N3245		— —	1.0 1.2	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic			Symbol	Min	Max	Unit
Base-Emitter Saturation Voltage(1)			$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)				—	1.1	
(I_C = 500 mAdc, I_B = 50 mAdc)				0.75	1.5	
(I_C = 1.0 Adc, I_B = 100 mAdc)				—	2.0	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product			f_T			MHz
(I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		2N3244		175	—	
		2N3245		150	—	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)			C_{obo}	—	25	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)			C_{ibo}	—	100	pF
SWITCHING CHARACTERISTICS						
Delay Time	(I_C = 500 mA, I_{B1} = 50 mA V_{EB} = 2.0 V, V_{CC} = 30 V)		t_d	—	15	ns
Rise Time		2N3244	t_r	—	35	ns
		2N3245		—	40	
Storage Time	(I_C = 500 mA, V_{CC} = 30 V I_{B1} = I_{B2} = 50 mA)	2N3244	t_s	—	140	ns
		2N3245			120	
Fall Time			t_f	—	45	ns
Total Control Charge			Q_T			pC
(I_C = 500 mA, I_B = 50 mA, V_{CC} = 30 V)		2N3244		—	14	
		2N3245		—	12	

(1) Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — MINIMUM CURRENT GAIN CHARACTERISTICS

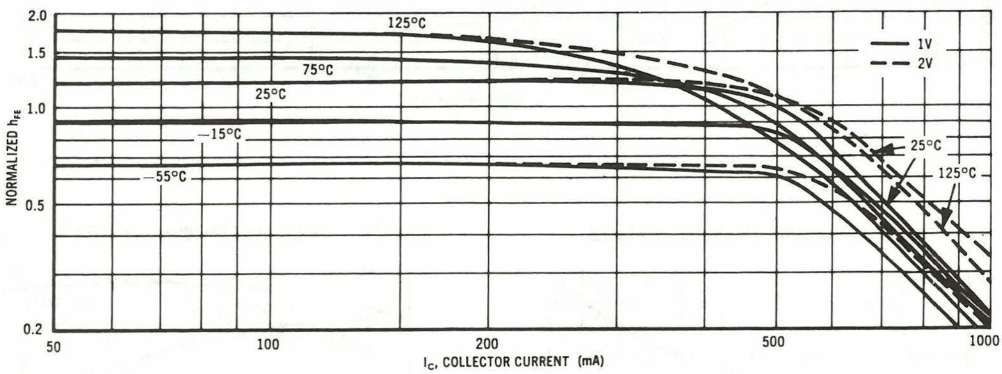


FIGURE 2 — COLLECTOR-EMITTER SATURATION VOLTAGE CHARACTERISTICS

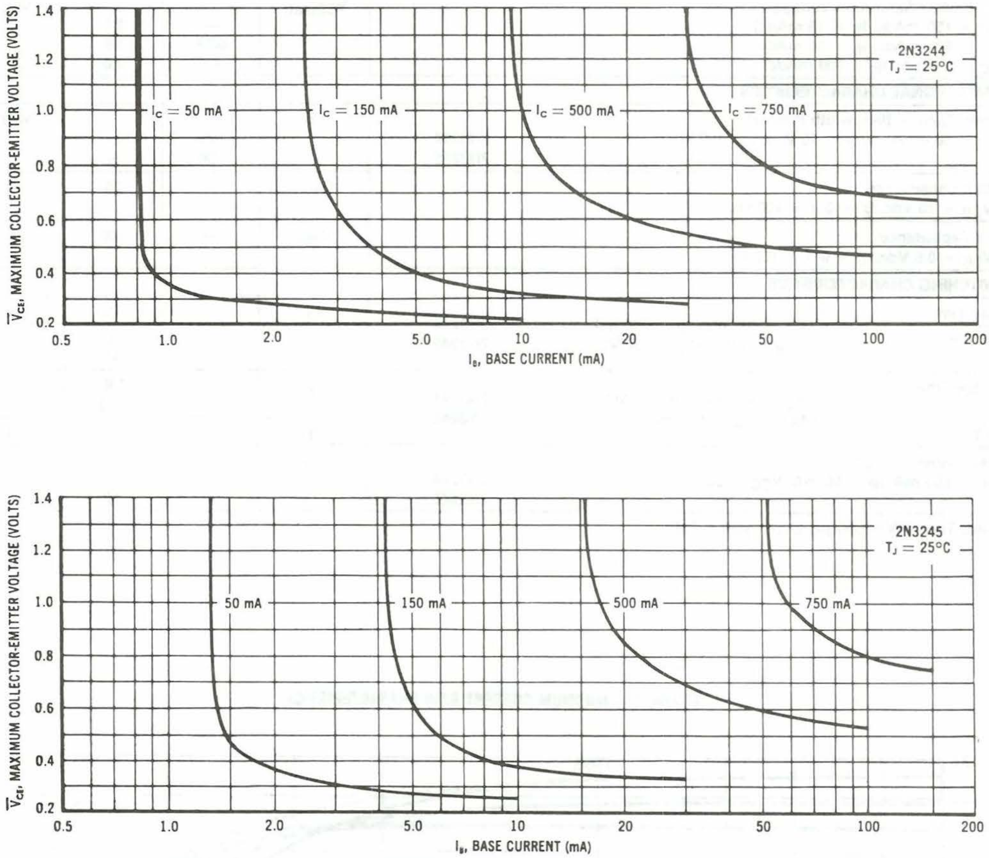


FIGURE 3 — MAXIMUM SATURATION VOLTAGES

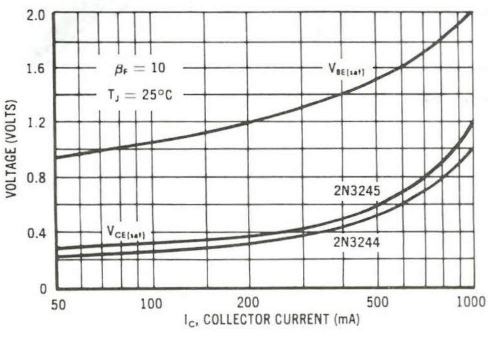


FIGURE 4 — TYPICAL TEMPERATURE COEFFICIENTS

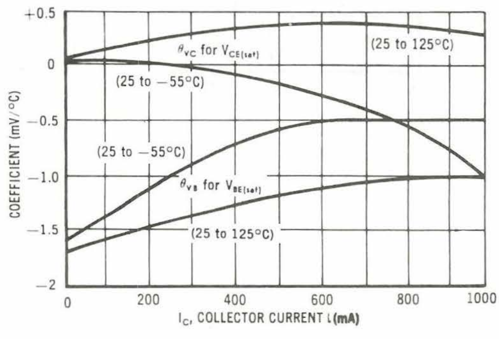


FIGURE 5 — JUNCTION CAPACITANCE

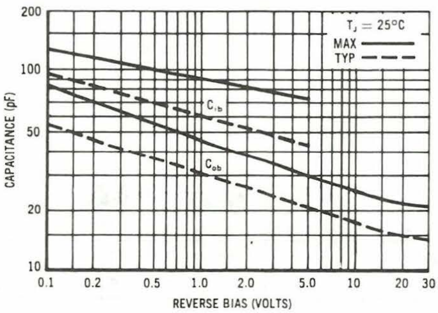


FIGURE 6 — TYPICAL SWITCHING TIMES

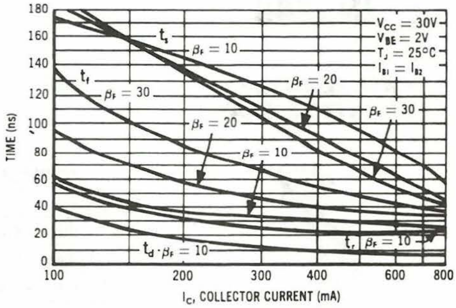


FIGURE 7 — CHARGE DATA

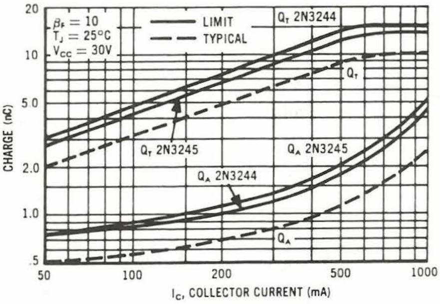


FIGURE 8 — TURN-ON EQUIVALENT TEST CIRCUIT

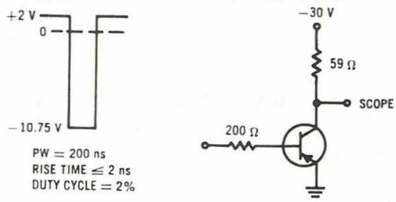


FIGURE 9 — TURN-OFF EQUIVALENT TEST CIRCUIT

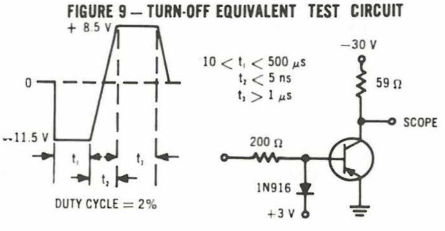


FIGURE 10 — Q_T TEST CIRCUIT

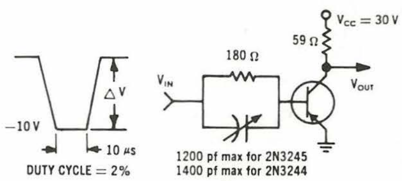
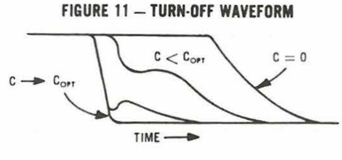


FIGURE 11 — TURN-OFF WAVEFORM



4

2N3249

CASE 22, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	15	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	200	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.9	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	12	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	15	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Base Cutoff Current (V_{CE} = 10 Vdc, V_{BE} = 1.0 Vdc)	I_{BEV}	—	50	nAdc
Collector Cutoff Current (V_{CE} = 10 Vdc, V_{BE} = 1.0 Vdc) (V_{CE} = 10 Vdc, V_{BE} = 1.0 Vdc, T_A = 100°C)	I_{CEX}	 — —	 0.05 5.0	μAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 100 100 100 75 35	 300 — — — —	—
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	 — — —	 0.125 0.25 0.45	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	 0.6 0.7 —	 0.9 1.1 1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	8.0	pF
Input Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	8.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS					
Delay Time	I_C = 100 mA, I_B = 10 mA, V_{BE} = 0.5 V, V_{CC} = 10 V	t_d	—	5.0	ns
Rise Time		t_r	—	15	ns
Storage Time	I_C = 100 mA, I_{B1} = I_{B2} = 10 mA, V_{CC} = 10 V	t_s	—	60	ns
Fall Time		t_f	—	20	ns
Turn-On Time	I_C = 10 mA, I_{B1} = 1.0 mA, V_{BE} = 0.5 V, V_{CC} = 3.0 V	t_{on}	—	90	ns
Turn-Off Time	I_C = 10 mA, I_{B1} = I_{B2} = 1.0 mA, V_{CC} = 3.0 V	t_{off}	—	100	ns
Total Control Charge (I_C = 10 mA, I_B = 0.25 mA, V_{CC} = 3.0 V)		Q_T	—	150	pC

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — t_{on} CIRCUIT

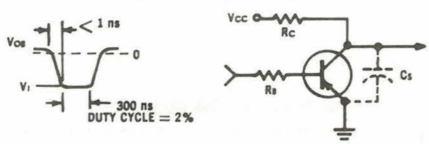
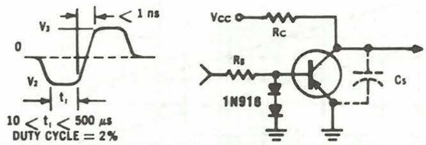


FIGURE 2 — t_{off} CIRCUIT



I_C mA	V_{CC} volts	R_B ohms	R_C ohms	$C_{S(max)}$* pF	V_{OB} volts	V_1 volts	V_2 volts	V_3 volts
10	3	10 K	285	4	+0.5	−10.6	−10.9	+9.1
100	10	1 K	95	12	+0.5	−10.7	−11.3	+8.7

*Total shunt capacitance of test jig and connectors.

FIGURE 3 — TYPICAL SWITCHING TIMES

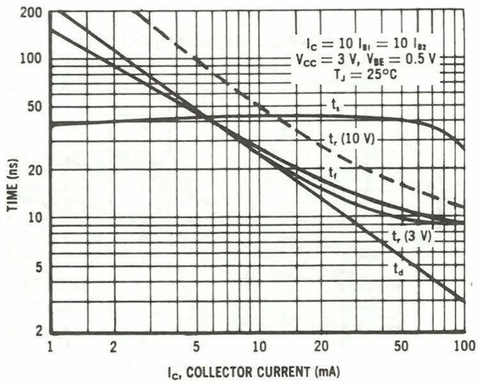
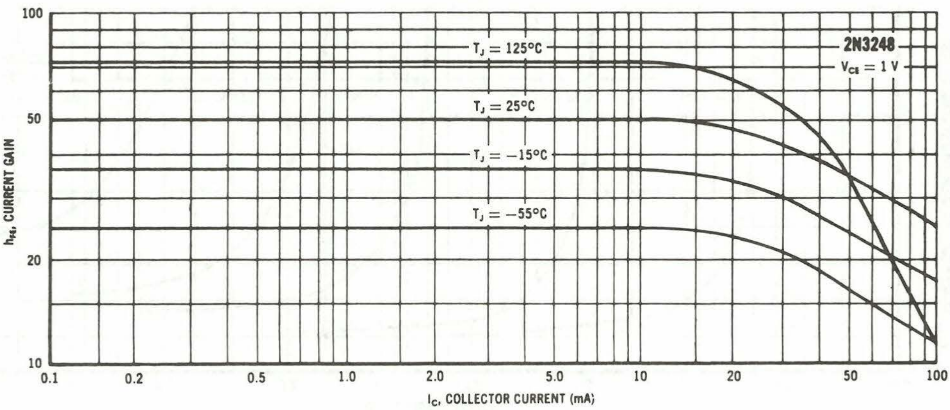
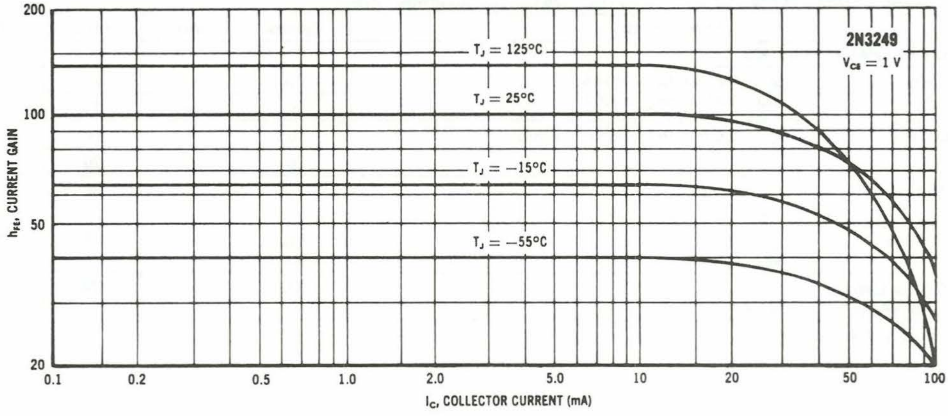


FIGURE 4 — MINIMUM CURRENT GAIN CHARACTERISTICS





4

FIGURE 5 — MAXIMUM CHARGE DATA

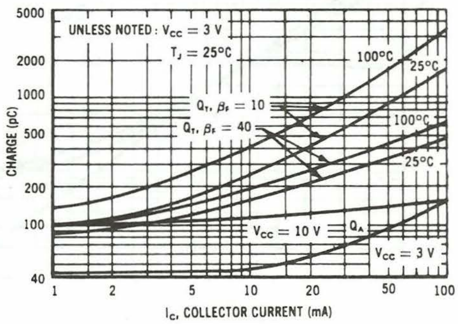


FIGURE 6 — JUNCTION CAPACITANCE

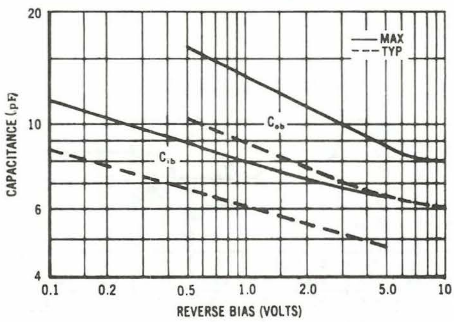
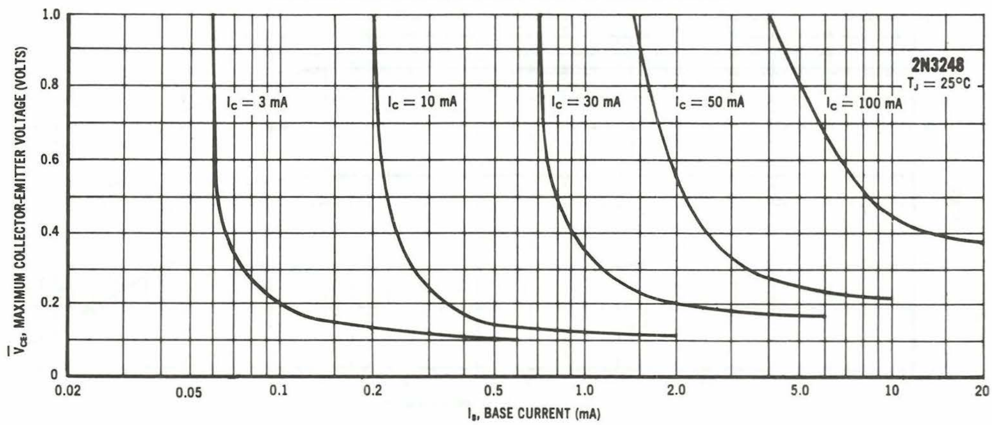
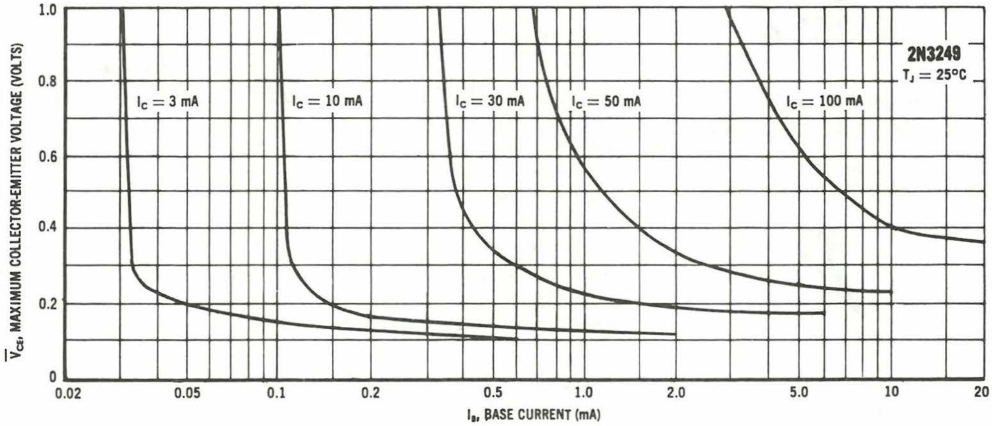


FIGURE 7 COLLECTOR SATURATION VOLTAGE CHARACTERISTICS





4

FIGURE 8 — SATURATION VOLTAGE LIMITS

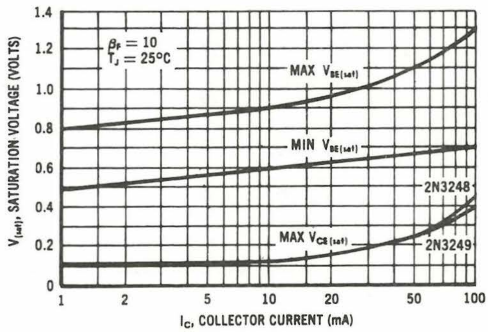


FIGURE 9 — TYPICAL TEMPERATURE COEFFICIENTS

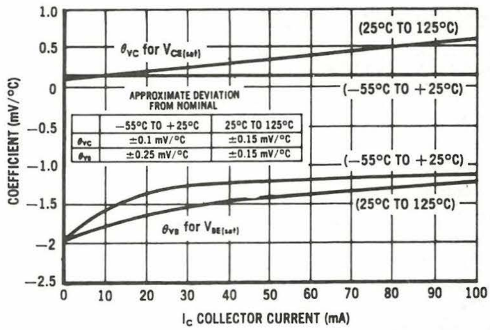


FIGURE 10 — Q_T TEST CIRCUIT

VALUES REFER TO $I_C = 10$ mA TEST POINT

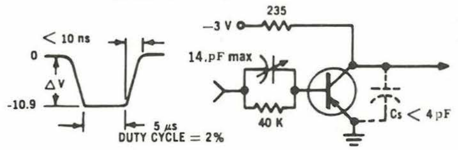
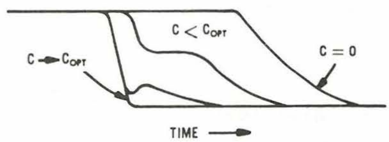


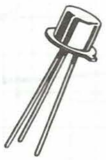
FIGURE 11 — TURN-OFF WAVE FORM



2N3250,A
2N3251,A

2N3250A,2N3251A
JAN, JTX, JTXV AVAILABLE

CASE 22, STYLE 1
TO-18 (TO-206AA)



GENERAL PURPOSE TRANSISTOR
PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	2N3250 2N3251	2N3250A 2N3251A	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	50	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current	I_C	200		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.9		Watts mW/°C
Operating and Storage Temperature Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.15	mW/°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.49	mW/°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc)	2N3250, 2N3251 2N3250A, 2N3251A	$V_{(BR)CEO}$	40 60	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc)	2N3250, 2N3251 2N3250A, 2N3251A	$V_{(BR)CBO}$	50 60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 40 Vdc, V_{BE} = 3.0 Vdc)		I_{CEX}	—	20	Adc
Base Cutoff Current (V_{CE} = 40 Vdc, V_{BE} = 3.0 Vdc)		I_{BL}	—	50	nAdc
ON CHARACTERISTICS					
DC Forward Current Transfer Radio (1)		h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	2N3250, 2N3250A 2N3251, 2N3251A		40 80	— —	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	2N3250, 2N3250A 2N3251, 2N3251A		45 90	— —	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N3250, 2N3250A 2N3251, 2N3251A		50 100	150 300	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	2N3250, 2N3250A 2N3251, 2N3251A		15 30	— —	
Collector-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	 — —	 0.25 0.5	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{BE(sat)}$	 0.6 —	 0.9 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N3250, 2N3250A 2N3251, 2N3251A	f_T	250 300	— —	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	6.0	pF
Input Capacitance (V_{CB} = 1.0 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	8.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Input Impedance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)	2N3250, 2N3250A 2N3251, 2N3251A	h_{ie}	1.0 2.0	6.0 12	kohms
Voltage Feedback Ratio (I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)	2N3250, 2N3250A 2N3251, 2N3251A	h_{re}	— —	10 20	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)	2N3250, 2N3250A 2N3251, 2N3251A	h_{fe}	50 100	200 400	—
Output Admittance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)	2N3250, 2N3250A 2N3251, 2N3251A	h_{oe}	4.0 10	40 60	μmhos
Collector Base Time Constant (I_C = 10 mA, V_{CE} = 20 V)		$rb'C_C$	—	250	ps
Noise Figure (I_C = 100 μA, V_{CE} = 5.0 V, R_S = 1.0 k Ω, f = 100 Hz)		NF	—	6.0	dB

SWITCHING CHARACTERISTICS

Characteristic			Symbol	Max	Unit
Delay Time	(V_{CC} = 3.0 Vdc, V_{BE} = 0.5 Vdc I_C = 10 mAdc, I_{B1} = 1.0 mA)		t_d	35	ns
Rise Time			t_r	35	ns
Storage Time	(I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc V_{CC} = 3.0 V)	2N3250, 2N3250A 2N3251, 2N3251A	t_s	175 200	ns
Fall Time			t_f	50	ns

(1) Pulse Test: PW = 300 μs, Duty Cycle = 2.0%.

4

SWITCHING TIME CHARACTERISTICS

FIGURE 1 — DELAY AND RISE TIME

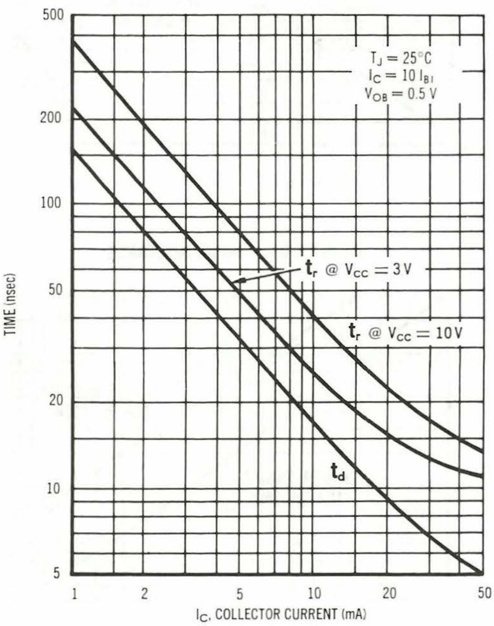
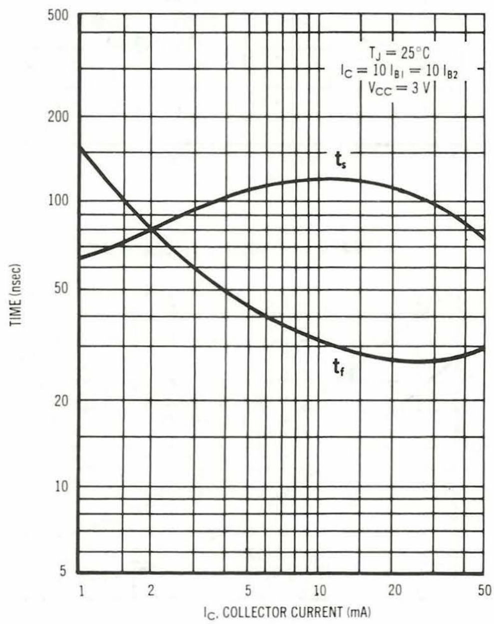


FIGURE 2 — STORAGE AND FALL TIME



4

AUDIO SMALL SIGNAL CHARACTERISTICS
NOISE FIGURE VARIATIONS
(V_{CE} = 6V, T_A = 25°C)

FIGURE 3 — FREQUENCY

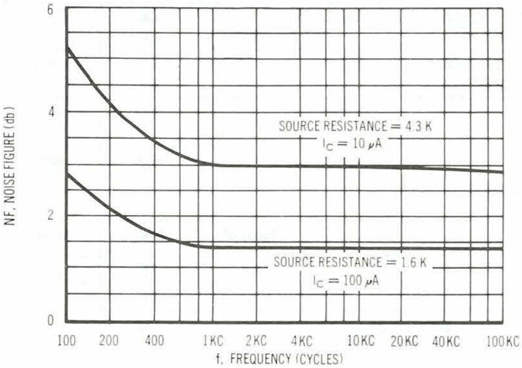
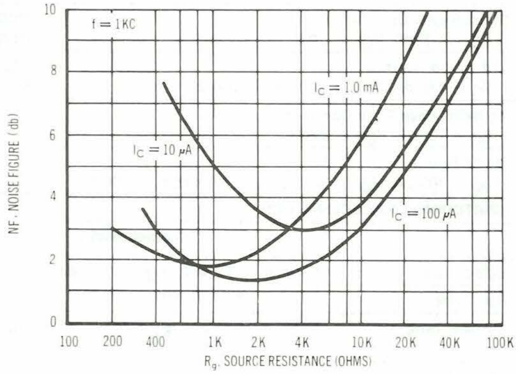


FIGURE 4 — SOURCE RESISTANCE



h PARAMETERS
V_{CE} = 10V, f = 1 kc, T_A = 25°C

FIGURE 5 — CURRENT GAIN

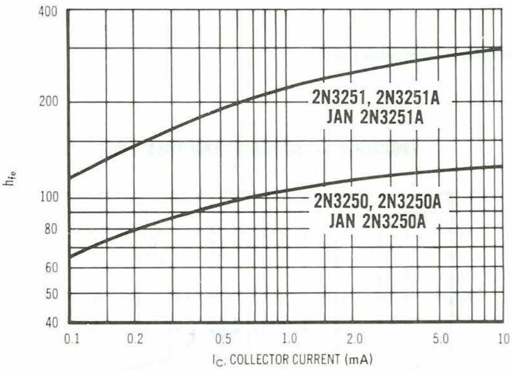


FIGURE 6 — OUTPUT ADMITTANCE

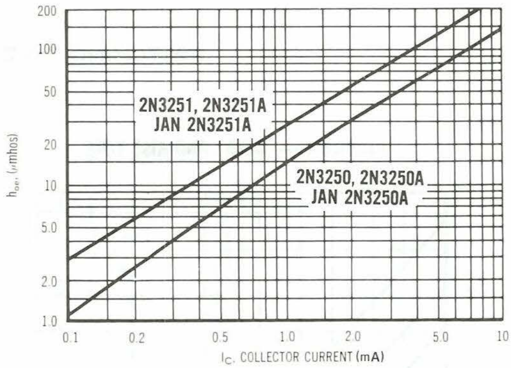


FIGURE 7 — VOLTAGE FEEDBACK RATIO

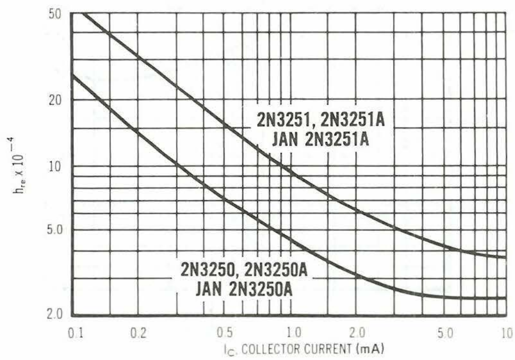


FIGURE 8 — INPUT IMPEDANCE

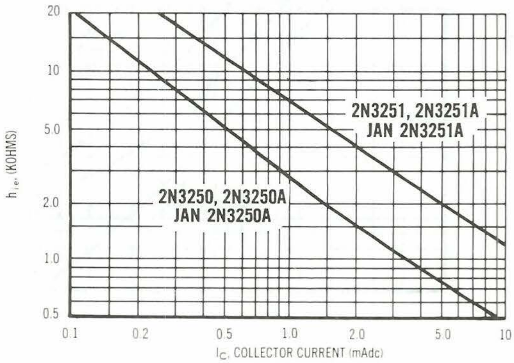


FIGURE 9 — NORMALIZED CURRENT GAIN CHARACTERISTICS

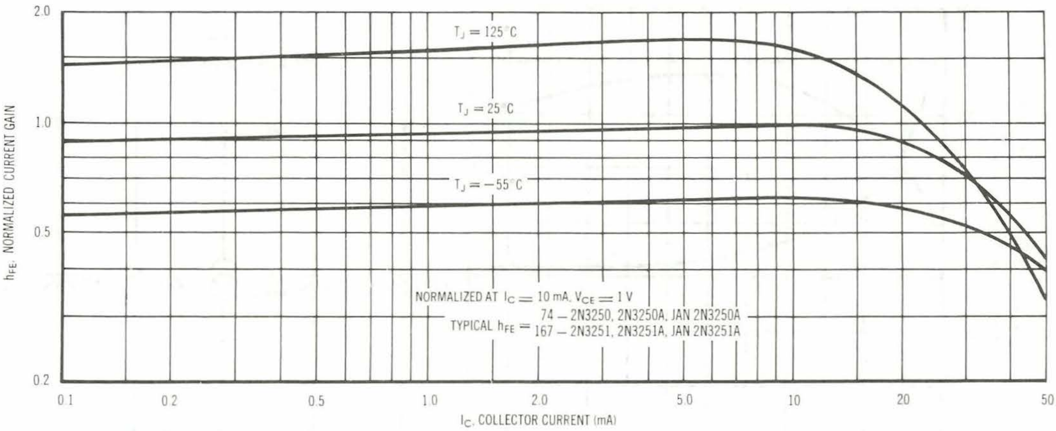
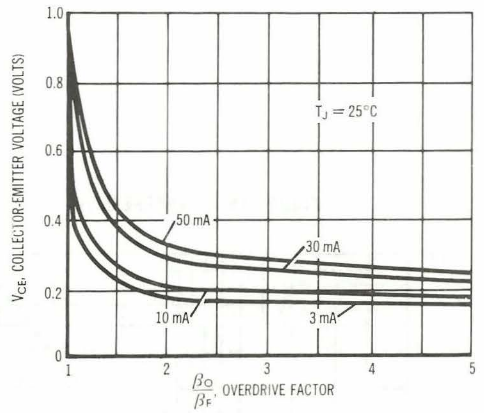


FIGURE 10 — COLLECTOR SATURATION REGION



This graph shows the effect of base current on collector current. β_O is the current gain of the transistor at 1 volt, and β_F (forced gain) is the ratio of I_C/I_{BF} in a circuit. EXAMPLE: For type 2N3251, estimate a base current (I_{BF}) to insure saturation at a temperature of 25°C and a collector current of 10 mA.

Observe that at $I_C = 10$ mA an overdrive factor of at least 2.5 is required to drive the transistor well into the saturation region. From Figure 1, it is seen that h_{FE} @ 1 volt is typically 167 (guaranteed limits from the Table of Characteristics can be used for "worst-case" design) . . .

$$\frac{\beta_O}{\beta_F} = \frac{h_{FE} @ 1\ \text{Volt}}{I_C/I_{BF}} \qquad 2.5 = \frac{167}{10\ \text{mA}/I_{BF}} \qquad I_{BF} \approx 6.68\ \text{mA typ}$$

FIGURE 11 — SATURATION VOLTAGES

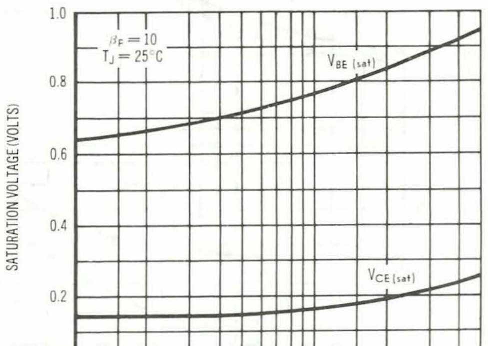
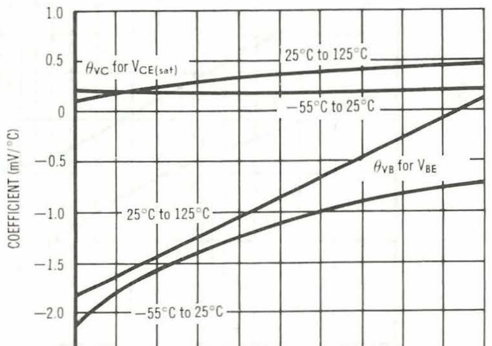


FIGURE 12 — TEMPERATURE COEFFICIENTS



4

FIGURE 13 — f_T AND $r_b'C_C$ versus I_C

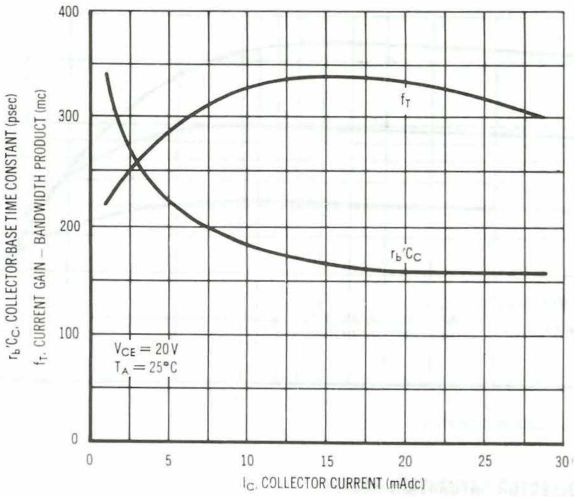


FIGURE 14 — 30 MC EQUIVALENT CIRCUIT

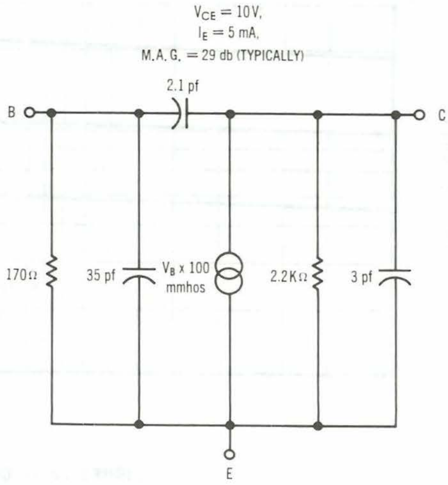


FIGURE 15 — JUNCTION CAPACITANCE

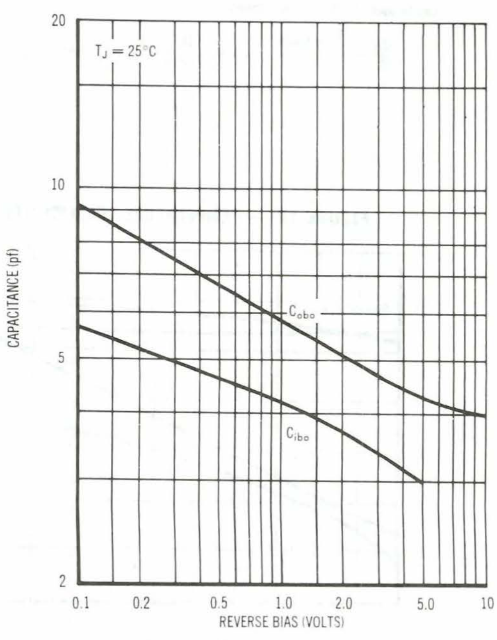
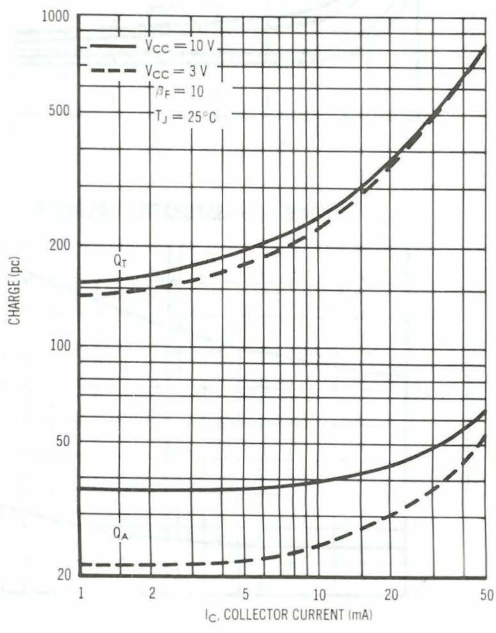
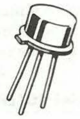


FIGURE 16 — CHARGE DATA



2N3252
2N3253
2N3444

JAN, JTX AVAILABLE
2N3253, 2N3444
CASE 79, STYLE 1
TO-39 (TO-205AD)



SWITCHING

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N3252	2N3253	2N3444	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	50	Vdc
Collector-Base Voltage	V_{CBO}	60	75	80	Vdc
Emitter-Base Voltage	V_{EBO}		5.0		Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D		1.0 5.71		Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D		5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$ $R_{\theta JA}$	35 0.175	°C/W °C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

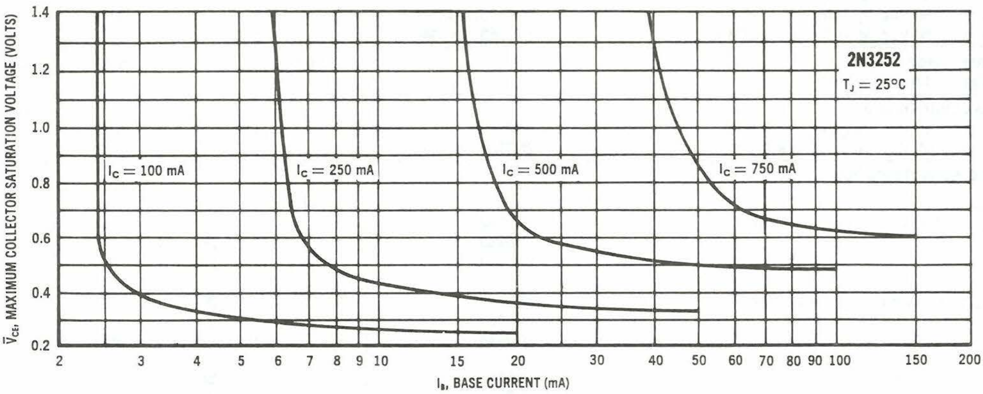
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, pulsed, I_B = 0)	 2N3252 2N3253 2N3444	$V_{(BR)CEO}$	 30 40 50	 — — —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	 2N3252 2N3253 2N3444	$V_{(BR)CBO}$	 60 75 80	 — — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 40 Vdc, $V_{EB(off)}$ = 4.0 Vdc) (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 4.0 Vdc)	 2N3252 2N3253, 2N3444	I_{CEX}	 — —	 0.5 0.5	μAdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0, T_A = 100°C) (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0, T_A = 100°C)	 2N3252 2N3252 2N3253, 2N3444 2N3253, 2N3444	I_{CBO}	 —	 0.50 75.0 0.50 75.0	μAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)		I_{EBO}	—	0.05	μAdc
Base Cutoff Current (V_{CE} = 40 Vdc, $V_{EB(off)}$ = 4.0 Vdc) (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 4.0 Vdc)	 2N3252 2N3253, 2N3444	I_{BL}	 — —	 0.50 0.50	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 150 mAdc, V_{CE} = 1.0 Vdc)	 2N3252 2N3253 2N3444	h_{FE}	 30 25 20	 — — —	—
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	2N3252 2N3253 2N3444		30 25 20	90 75 60	
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	2N3252 2N3253 2N3444		25 20 15	— — —	

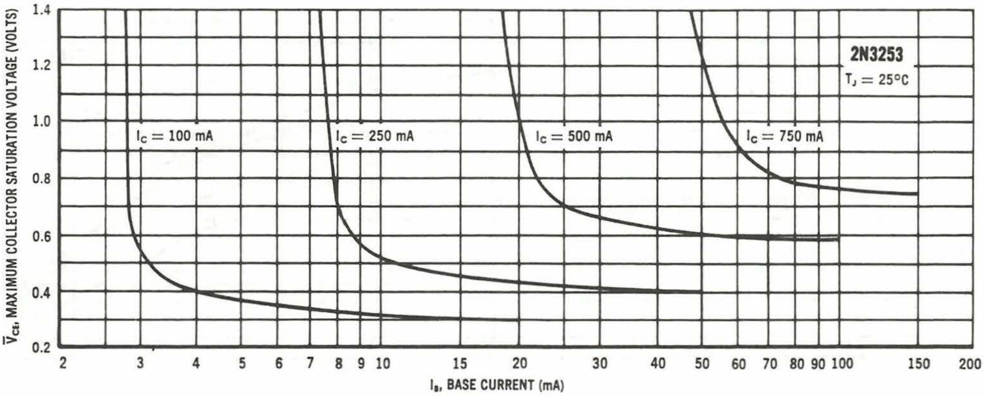
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	2N3252		—	0.3	
	2N3253, 2N3444		—	0.35	
(I_C = 500 mAdc, I_B = 500 mAdc)	2N3252		—	0.5	
	2N3253, 2N3444		—	0.60	
(I_C = 1.0 Adc, I_B = 100 mAdc)	2N3252		—	1.0	
	2N3253, 2N3444		—	1.2	
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	1.0	
(I_C = 500 mAdc, I_B = 50 mAdc)			0.7	1.3	
(I_C = 1.0 Adc, I_B = 100 mAdc)			—	1.8	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product		f_T			MHz
(I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N3252		200	—	
	2N3253, 2N3444		175	—	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	12	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	80	pF
SWITCHING CHARACTERISTICS					
Delay Time	I_C = 500 mAdc, I_{B1} = 50 mAdc	t_d	—	15	ns
Rise Time	V_{CC} = 30 V, V_{BE} = 2.0 V 2N3252	t_r	—	30	ns
	2N3253, 2N3444		—	35	
Storage Time	I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc	t_s	—	40	ns
Fall Time	V_{CC} = 30 V	t_f	—	30	ns
Total Control Charge (I_C = 500 mAdc, I_{B1} = 50 mAdc, V_{CC} = 30 V)		Q_T	—	5.0	nC

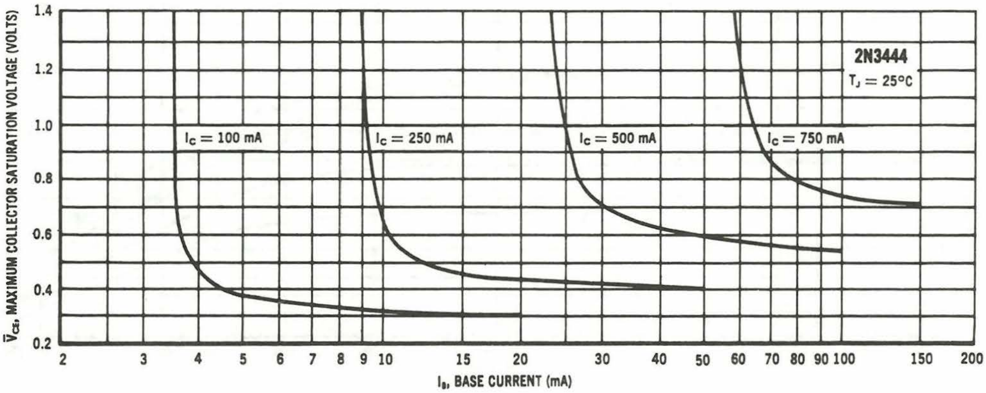
(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

COLLECTOR SATURATION VOLTAGE CHARACTERISTICS

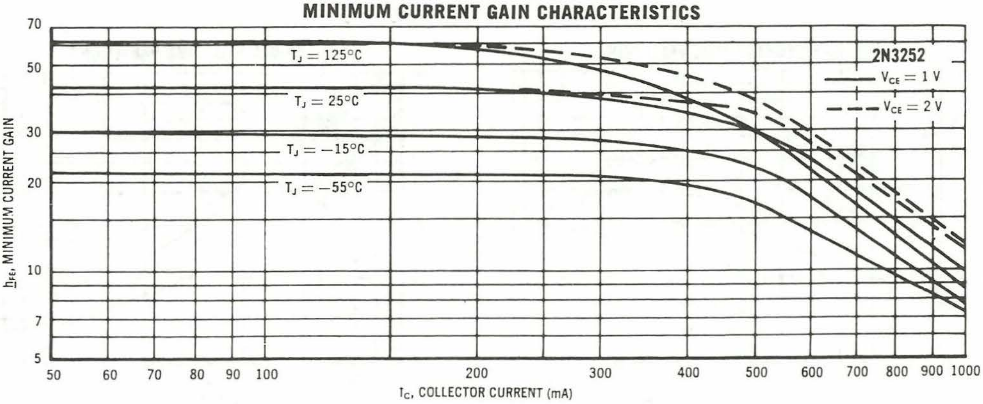


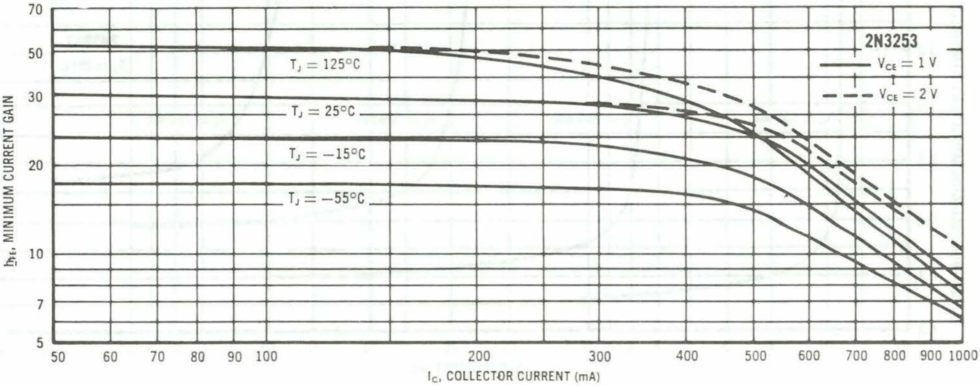


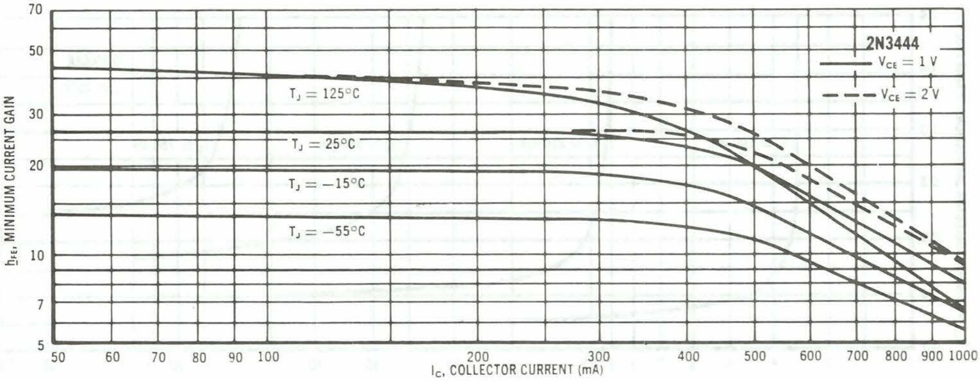
4



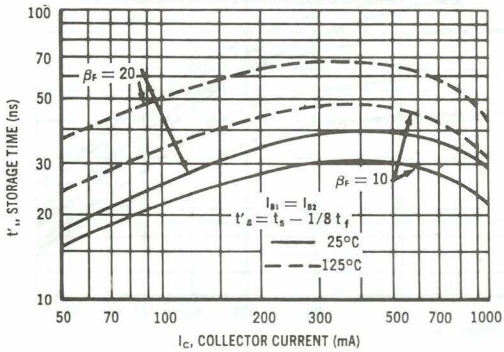
MINIMUM CURRENT GAIN CHARACTERISTICS



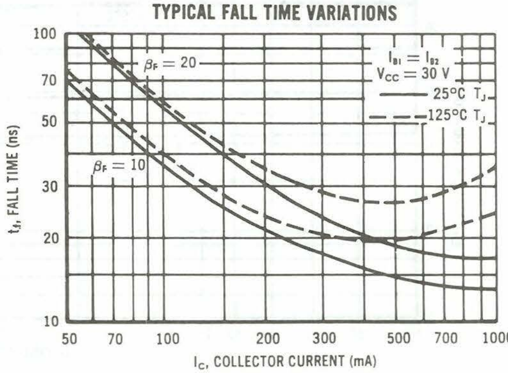




TYPICAL STORAGE TIME VARIATIONS

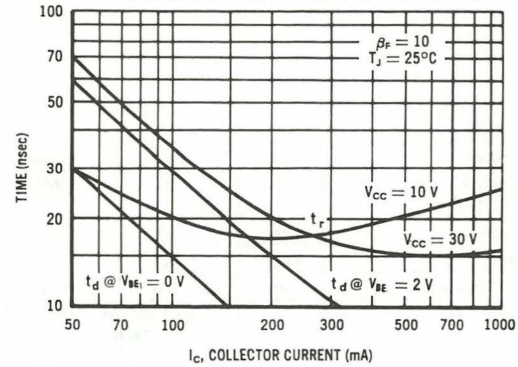


TYPICAL FALL TIME VARIATIONS

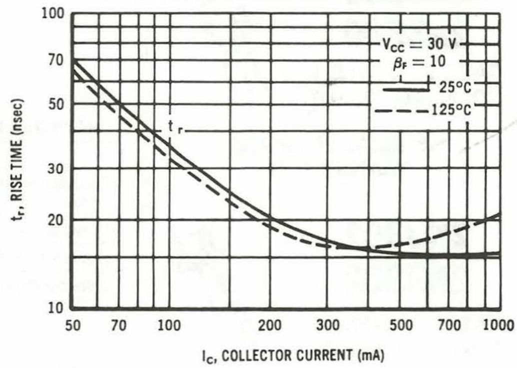


4

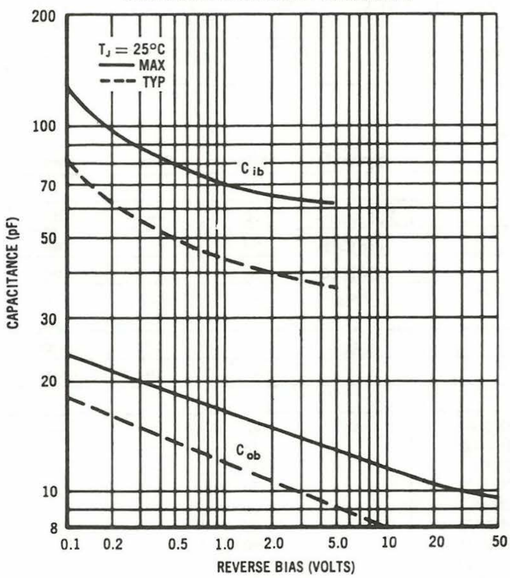
TYPICAL TURN-ON TIME VARIATIONS WITH VOLTAGE



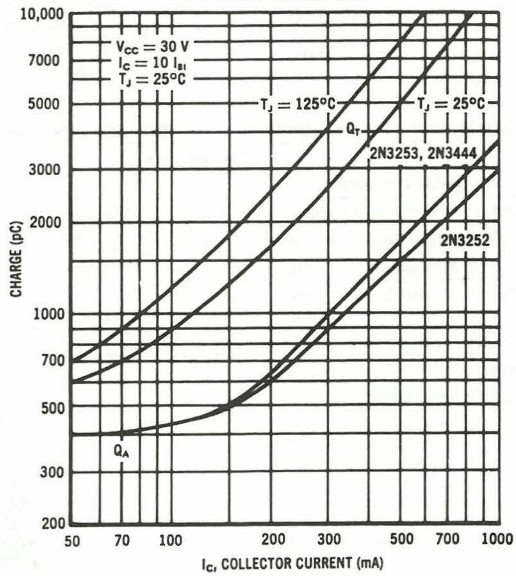
TYPICAL RISE TIME VARIATIONS WITH TEMPERATURE



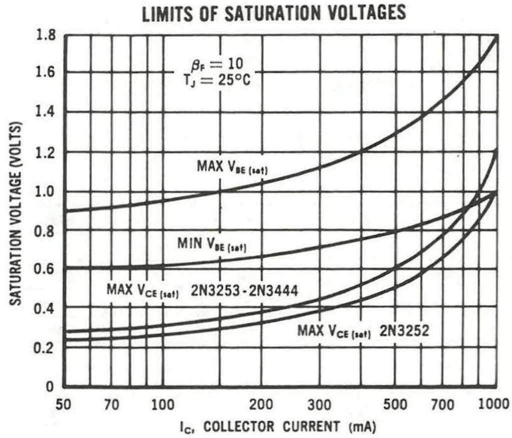
JUNCTION CAPACITANCE VARIATIONS



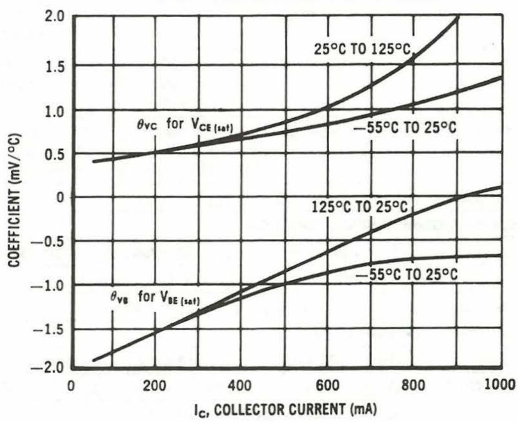
MAXIMUM CHARGE DATA



LIMITS OF SATURATION VOLTAGES



TYPICAL TEMPERATURE COEFFICIENTS



2N3299
2N3300

CASE 79, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

2N3301
2N3302

CASE 22, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N2218 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage (Applicable 0 to 10 mAdc)	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		2N3299 2N3300	**2N3301 2N3302**	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.8 4.56	0.36 2.06	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	3.0 17.2	1.8 10.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)		$V_{CEO(sus)}$	30	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)		$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 50$ Vdc, $V_{BE} = 0$) ($V_{CE} = 50$ Vdc, $V_{BE} = 0$, $T_A = 150°C$)		I_{CES}	— —	0.01 10	μAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	10	nAdc
Base Current ($V_{CE} = 50$ Vdc, $V_{BE} = 0$)		I_B	—	10	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)(1) ($I_C = 150$ mAdc, $V_{CE} = 1.0$ Vdc)(1) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)(1) ($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc)(1)	2N3299, 2N3301 2N3300, 2N3302 2N3299, 2N3301 2N3300, 2N3302 2N3299, 2N3301 2N3300, 2N3302 2N3299, 2N3301 2N3300, 2N3302 2N3299, 2N3301 2N3300, 2N3302 2N3299, 2N3301 2N3300, 2N3302	h_{FE}	20 35 25 50 35 75 20 50 40 100 20 50	— — — — — — — — 120 300 — —	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 300$ mAdc, $I_B = 30$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)		$V_{CE(sat)}$	— — —	0.22 0.45 0.6	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 300$ mAdc, $I_B = 30$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)		$V_{BE(sat)}$	— — —	1.1 1.3 1.5	Vdc
Base Emitter Voltage ($I_C = 150$ mA, $V_{CE} = 10$ V)		$V_{BE(on)}$	—	1.1 V	Max
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)		f_T	250	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 140 kHz)		C_{obo}	—	8.0	pF
Input Capacitance ($V_{BE} = 2.0$ Vdc, $I_C = 0$, f = 140 kHz)		C_{ibo}	—	20	pF
SWITCHING CHARACTERISTICS					
Turn-On Time ($V_{CC} = 25$ Vdc, $I_C = 300$ mAdc, $I_{B1} = 30$ mAdc)		t_{on}	—	60	ns
Turn-Off Time ($V_{CC} = 25$ Vdc, $I_C = 300$ mAdc, $I_{B1} = I_{B2} = 30$ mAdc)		t_{off}	—	150	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N3307
2N3308

CASE 20, STYLE 10
TO-72 (TO-206AF)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	2N3307	2N3308	Unit
Collector-Emitter Voltage	V_{CEO}	35	25	Vdc
Collector-Emitter Voltage	V_{CES}	40	30	Vdc
Collector-Base Voltage	V_{CBO}	40	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	200 1.14		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	300 1.71		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

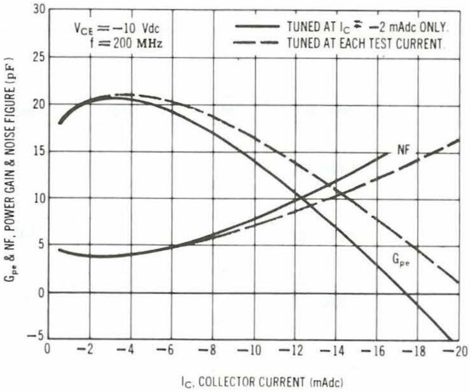
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 2.0$ mAdc, $I_B = 0$)	2N3307 2N3308	$V_{(BR)CEO}$	35 25	— —	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10$ μAdc, $V_{BE} = 0$)	2N3307 2N3308	$V_{(BR)CES}$	40 30	— —	Vdc
Collector-Base Breakdown Voltage(1) ($I_C = 10$ μAdc, $I_E = 0$)	2N3307 2N3308	$V_{(BR)CBO}$	40 30	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	3.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc) ($V_{CB} = 15$ Vdc, T = 150°C)	 2N3307	I_{CBO}	 — —	 0.010 3.0	μAdc
ON CHARACTERISTICS					
DC Current Gain ($V_{CE} = 10$ Vdc, $I_C = 2.0$ mAdc)	2N3307 2N3308	h_{FE}	40 25	250 250	—
Collector-Emitter Saturation Voltage ($I_C = 3.0$ mAdc, $I_B = 0.6$ mAdc)		$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 3.0$ mAdc, $I_B = 0.6$ mAdc		$V_{BE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($V_{CE} = 10$ Vdc, $I_C = 2.0$ mAdc, f = 100 MHz		f_T	300	1200	MHz
Maximum Frequency of Operation ($V_{CE} = 10$ Vdc, $I_C = 2.0$ mAdc)		f_{max}	Typical 2000		MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 0.1 MHz	2N3307 2N3308	C_{obo}	— —	1.3 1.6	pF
Small-Signal Current Gain ($V_{CE} = 10$ Vdc, $I_C = 2.0$ mAdc, f = 1 kHz)	2N3307 2N3308	h_{fe}	40 25	250 250	—
Collector Base Time Constant ($V_{CB} = 10$ Vdc, $I_C = 2.0$ mAdc, f = 31.8 MHz)	2N3307 2N3308	$r_b'C_c$	2.0 2.0	15 20	ps

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

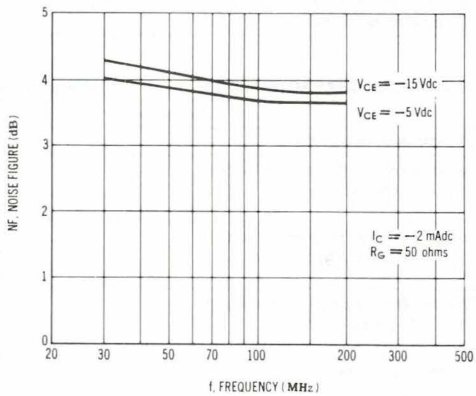
Characteristic		Symbol	Min	Max	Unit
Noise Figure (V_{CE} = 10 Vdc, I_C = 2.0 mAdc, f = 200 MHz)	2N3307 2N3308	NF	— —	4.5 6.0	dB
SWITCHING CHARACTERISTICS					
Power Gain(2) (V_{CE} = 10 Vdc, I_C = 2.0 mAdc, f = 200 MHz)		G_e	17	—	dB
Power Gain (AGC)(2) (V_{CE} = 5.0 Vdc, I_C = 20 mAdc, f = 200 MHz)	2N3307 2N3308	G_e	— —	0 —	dB

(1) C_{obo} is measured in guarded circuit such that the can capacitance is not included.
(2) AGC is obtained by increasing I_C. The circuit remains adjusted for V_{CE} = −10 Vdc, I_C = −2 mAdc operation.

COMMON EMITTER AVERAGE SMALL POWER GAIN & NOISE FIGURE versus COLLECTOR CURRENT



NOISE FIGURE versus FREQUENCY

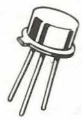


MAXIMUM RATINGS

Rating	Symbol	PNP 2N5415	PNP 2N5416	NPN 2N3439	NPN 2N3440	Unit
Collector-Emitter Voltage	V_{CEO}	200	300	350	250	Vdc
Collector-Base Voltage	V_{CBO}	200	350	450	300	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	6.0	7.0	7.0	Vdc
Base Current	I_B	0.5				Adc
Collector Current — Continuous	I_C	1.0				Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	— —		1.0 5.7		Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	10 57		5.0 28.6		Watts mW/°C
Total Device Dissipation @ T_A = 50°C Derate above 50°C	P_D	1.0 6.7		— —		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200				°C

2N3439, 2N3440 NPN
2N5415, 2N5416 PNP

JAN, JTX, JTXV AVAILABLE
CASE 79-02, STYLE 1
TO-39 (TO-205AD)



4

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N5415 2N5416	2N3439 2N3440	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	17.5	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	150	175	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1)		$V_{CEO(sus)}$			Vdc
(I_C = 50 mAdc, I_B = 0)	2N5415		200	—	
	2N5416		300	—	
	2N3439		350	—	
	2N3440		250	—	
*Collector Cutoff Current		I_{CEO}			μAdc
(V_{CE} = 300 Vdc, I_B = 0)	2N3439		—	20	
(V_{CE} = 200 Vdc, I_B = 0)	2N3440		—	50	
*Collector Cutoff Current		I_{CEX}			μAdc
(V_{CE} = 450 Vdc, V_{BE} = 1.5 Vdc)	2N3439		—	500	
(V_{CE} = 300 Vdc, V_{BE} = 1.5 Vdc)	2N3440		—	500	
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 175 Vdc, I_E = 0)	2N5415		—	50	
(V_{CB} = 280 Vdc, I_E = 0)	2N5416		—	50	
(V_{CB} = 360 Vdc, I_E = 0)	2N3439		—	20	
(V_{CB} = 250 Vdc, I_E = 0)	2N3440		—	20	
Emitter Cutoff Current		I_{EBO}			μAdc
(V_{EB} = 4.0 Vdc, I_C = 0)	2N5415		—	20	
(V_{EB} = 6.0 Vdc, I_C = 0)	2N5416, 2N3439, 2N3440		—	20	
ON CHARACTERISTICS(1)					
DC Current Gain		h_{FE}			—
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	2N3439		30	—	
*(I_C = 20 mAdc, V_{CE} = 10 Vdc)	2N3439, 2N3440		40	160	
*(I_C = 50 mAdc, V_{CE} = 10 Vdc)	2N5415		30	150	
	2N5416		30	120	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 4.0 mAdc)	2N3439, 2N3440	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 4.0 mAdc)	2N3439, 2N3440	$V_{BE(sat)}$	—	1.3	Vdc

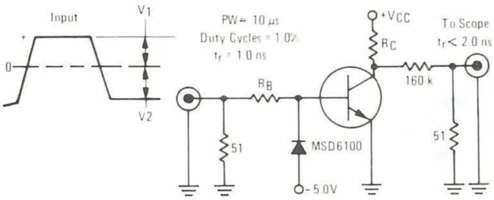
*Indicates Data in Addition to JEDEC Requirements.

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 5.0 MHz)	2N3439, 2N3440	f_T	15	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	2N5415, 2N5416, 2N3439, 2N3440	C_{obo}	— —	15 10	pF
Input Capacitance (V_{EB} = 5.0 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	75	pF
Small-Signal Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) (I_C = 10.0 mAdc, V_{CE} = 10 Vdc, f = 5.0 MHz)	2N5415, 2N5416	h_{fe}	25	—	—
Real Part of Input Impedance (V_{CE} = 10 Vdc, I_C = 5.0 mAdc, f = 1.0 MHz)		$Re(h_{ie})$	—	300	Ohms

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
CAUTION: The sustaining voltage *must not* be measured on a curve tracer. (See Fig. 15.)

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



NOTE: V_{CC} and R_C adjusted for $V_{CE(off)}$ = 150 V and I_C as desired, R_B chosen for desired I_{B1}, $V_1 \approx 10$ V, $V_2 \approx 8.0$ V

For t_d and t_r, D1 is disconnected and V_2 = 2.0 V

For PNP test circuit, reverse all polarities.

PNP 2N5415, 2N5416 | **NPN 2N3439, 2N3440**

FIGURE 2 – TURN-ON TIME

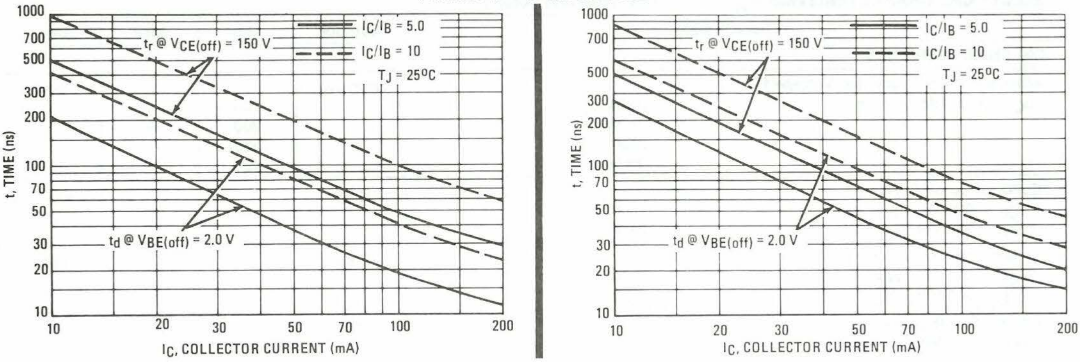


FIGURE 3 – TURN-OFF TIME

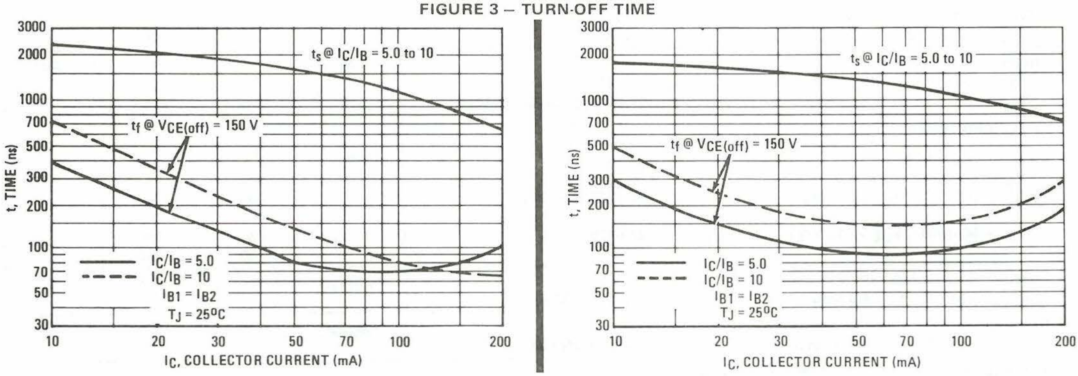


FIGURE 4 – CURRENT-GAIN – BANDWIDTH PRODUCT

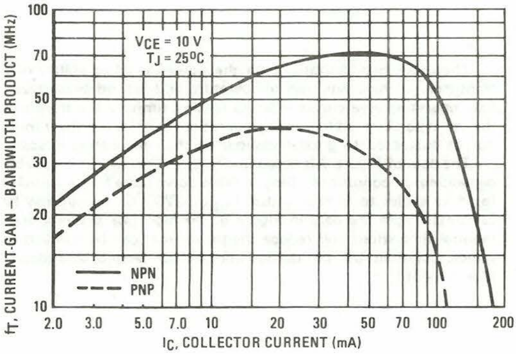


FIGURE 5 – CAPACITANCE

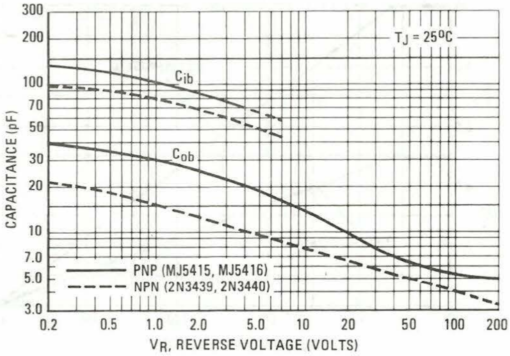


FIGURE 6 – THERMAL RESPONSE

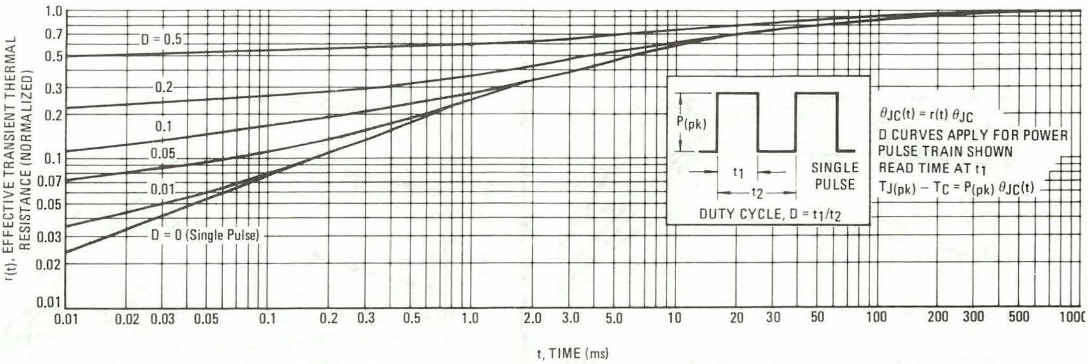
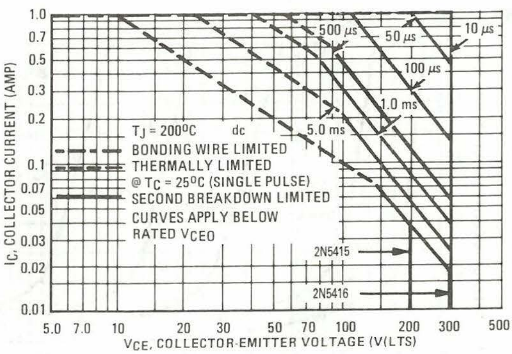


FIGURE 7 – ACTIVE-REGION SAFE OPERATING AREA

PNP — 2N5415, 2N5416



NPN – 2N3439, 2N3440

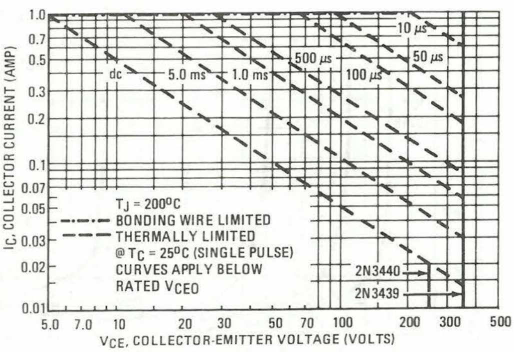
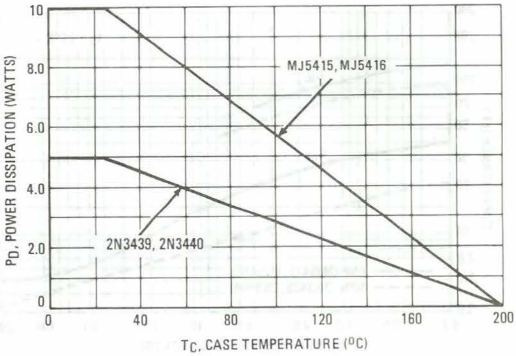


FIGURE 8 – POWER DERATING

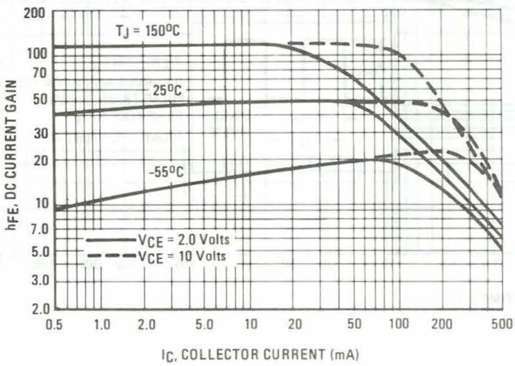


There are two limitations on the power handling ability of a transistor, average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 7 is based on $T_{J(pk)} = 200°C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

FIGURE 9 – DC CURRENT GAIN

PNP 2N5415, 2N5416



NPN 2N3439 2N3440

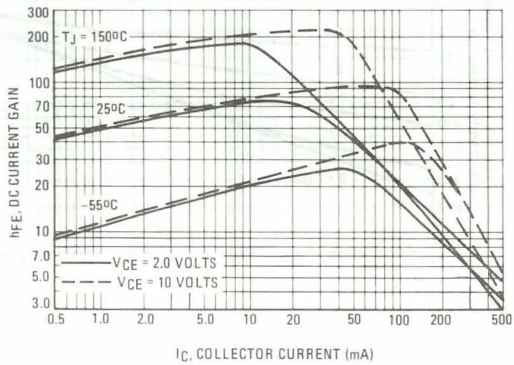
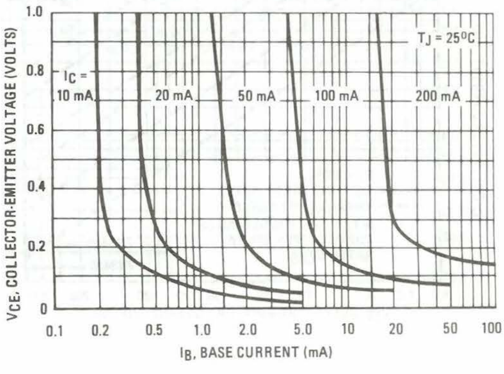


FIGURE 10 – COLLECTOR SATURATION REGION



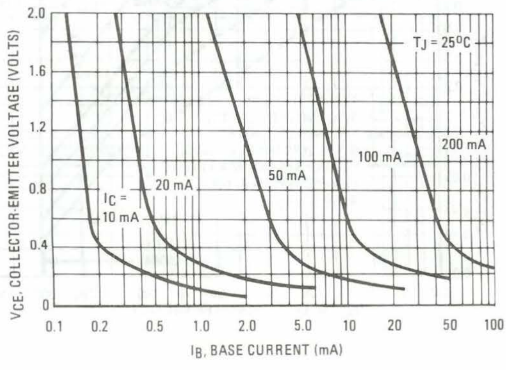


FIGURE 11 – "ON" VOLTAGES

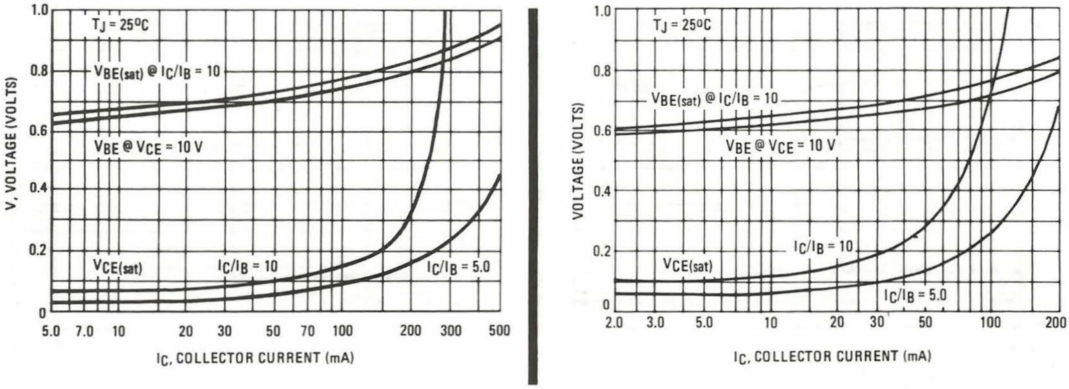


FIGURE 12 – TEMPERATURE COEFFICIENTS

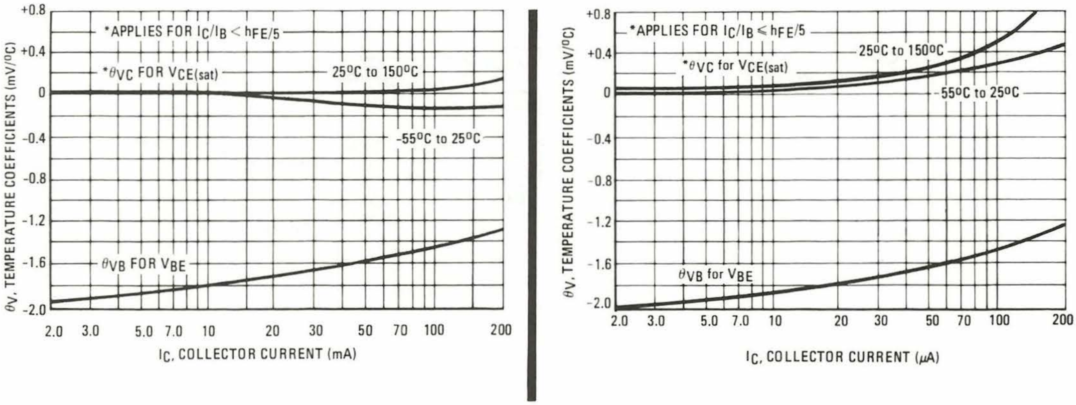


FIGURE 13 – COLLECTOR CUTOFF REGION

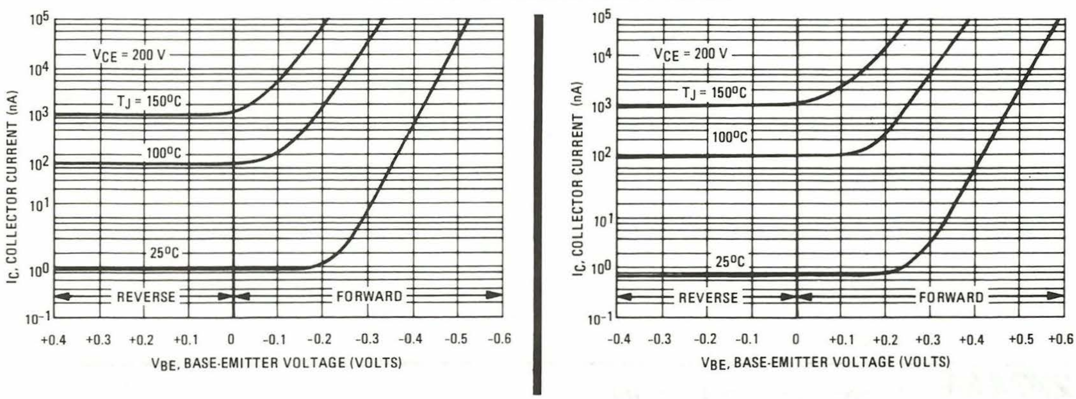
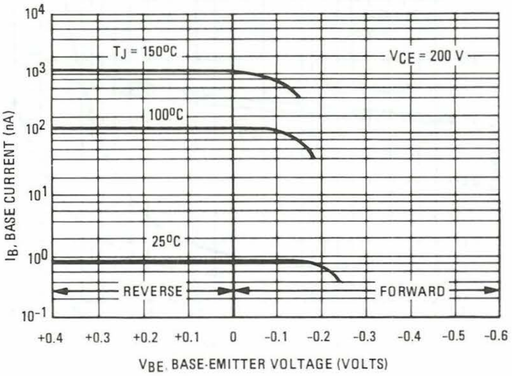


FIGURE 14 — BASE CUTOFF REGION



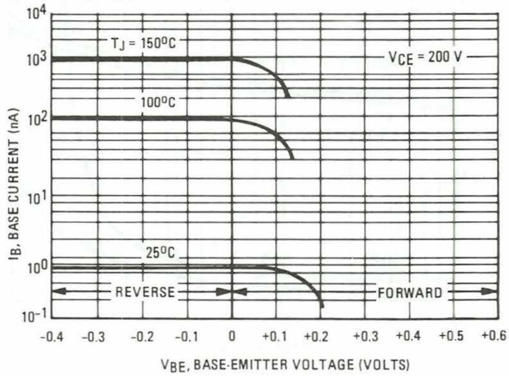
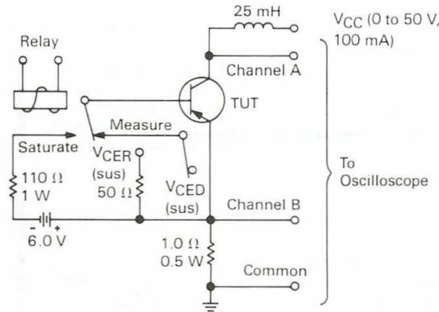


FIGURE 15 — CIRCUIT USED TO MEASURE SUSTAINING VOLTAGES



2N3444 For Specifications, See 2N3252 Data.

2N3467
2N3468

JAN, JTX, JTXV AVAILABLE

CASE 79-02, STYLE 1

TO-39 (TO-205AD)

SWITCHING TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N3467	2N3468	Unit
Collector-Emitter Voltage	V_{CEO}	40	50	Vdc
Collector-Base Voltage	V_{CBO}	40	50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.175	°C/mW

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	 2N3467 2N3468	$V_{(BR)CEO}$	 40 50	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	 2N3467 2N3468	$V_{(BR)CBO}$	 40 50	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Base Cutoff Current (V_{CE} = −30 Vdc, V_{BE} = 3.0 Vdc)		I_{BEV}	—	120	nAdc
Collector Cutoff Current (V_{CE} = −30 Vdc, V_{BE} = 3.0 Vdc)		I_{CEX}	—	100	nAdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 100°C)		I_{CBO}	 — —	 0.10 15	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 150 mAdc, V_{CE} = 1.0 Vdc)	 2N3467 2N3468	h_{FE}	 40 25	 — —	—
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	2N3467 2N3468		40 25	120 75	
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	2N3467 2N3468		40 20	— —	
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)	 2N3467 2N3468	$V_{CE(sat)}$	 — —	 0.3 0.36	Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)	2N3467 2N3468		— —	0.5 0.6	
(I_C = 1.0 Adc, I_B = 100 mAdc)	2N3467 2N3468		— —	1.0 1.2	
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1.0 Adc, I_B = 100 mAdc)		$V_{BE(sat)}$	 — 0.8 —	 1.0 1.2 1.6	Vdc

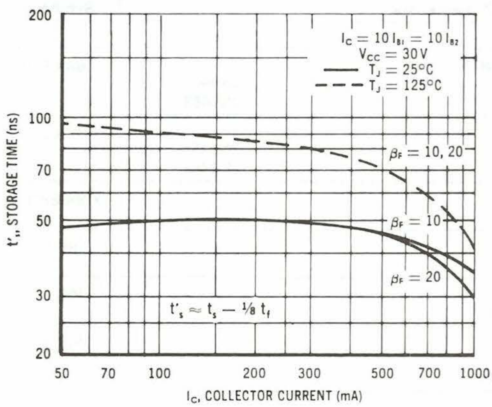
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N3467 2N3468	f_T	175 150	— —	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	25	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	100	pF
SWITCHING CHARACTERISTICS					
Delay Time	(I_C = 500 mA, I_{B1} = 50 mA, V_{BE} = 2.0 V, V_{CC} = 30 V)	t_d	—	10	ns
Rise Time		t_r	—	30	ns
Storage Time	(I_C = 500 mA, I_{B1} = I_{B2} = 50 mA, V_{CC} = 30 V)	t_s	—	60	ns
Fall Time		t_f	—	30	ns
Total Control Charge (I_C = 500 mA, I_B = 50 mA, V_{CC} = 30 V)		Q_T	—	6.0	nC

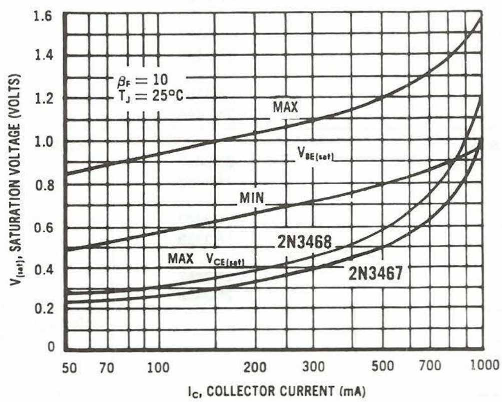
(1) Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2.0%.

4

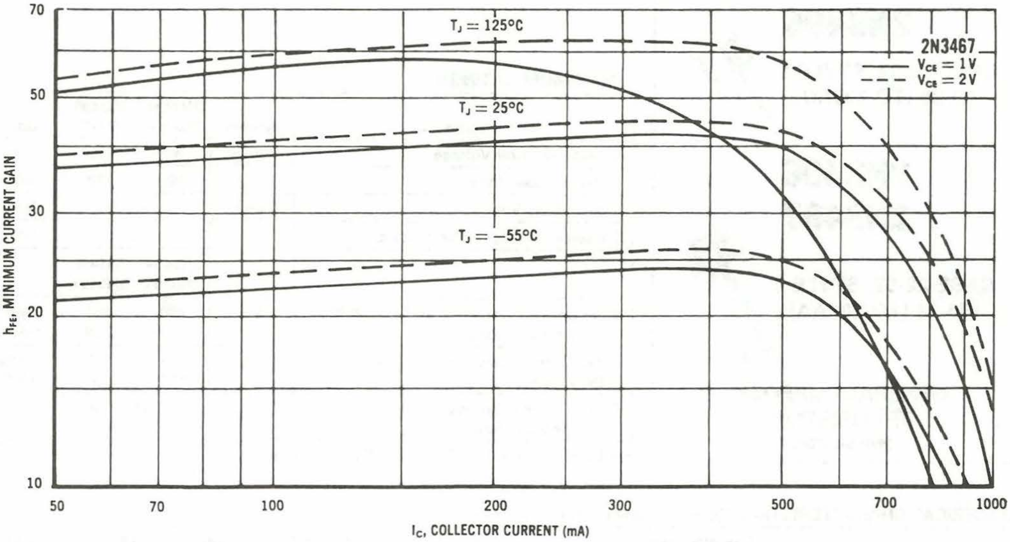
STORAGE TIME VARIATION WITH TEMPERATURE

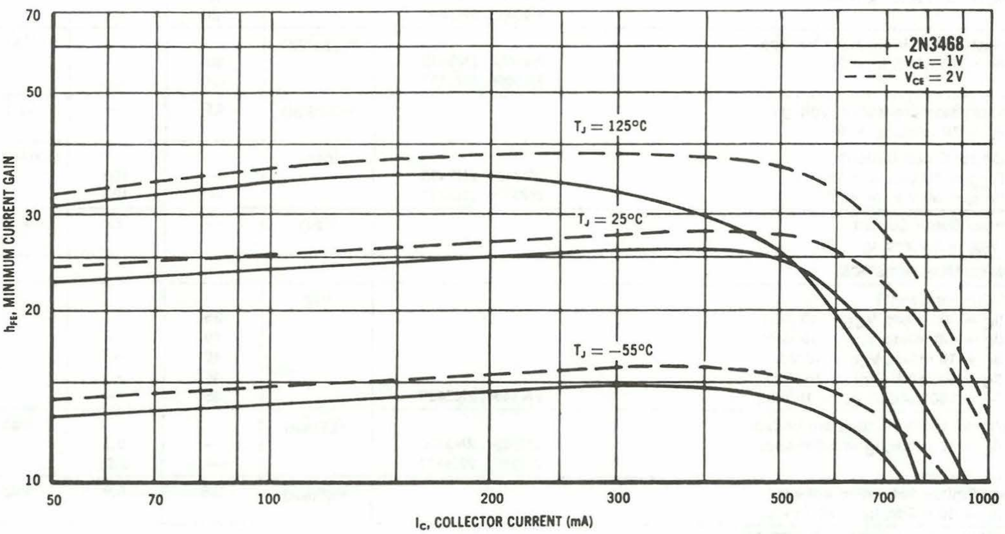


LIMITS OF SATURATION VOLTAGE



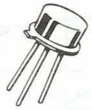
MINIMUM CURRENT GAIN CHARACTERISTICS





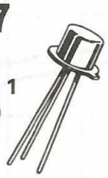
4

2N3494
2N3495



CASE 79-02, STYLE 1
TO-39 (TO-205AD)

2N3496
2N3497



CASE 22-03, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	2N3494 2N3496	2N3495 2N3497	Unit
Collector-Emitter Voltage	V_{CEO}	80	120	Vdc
Collector-Base Voltage	V_{CBO}	80	120	Vdc
Emitter-Base Voltage	V_{EBO}	4.5		Vdc
Collector Current — Continuous	I_C	100		mAdc
		2N3494 2N3495	**2N3496 2N3497**	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	600 3.43	400 2.28	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$* Derate above 25°C	P_D	3.0 17.2	1.2 6.85	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

*Indicates Data in addition to JEDEC Requirements.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	 2N3494, 2N3496 2N3495, 2N3497	$V_{(BR)CEO}$	 80 120	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	 2N3494, 2N3496 2N3495, 2N3497	$V_{(BR)CBO}$	 80 120	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	4.5	—	Vdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$) ($V_{CB} = 90$ Vdc, $I_E = 0$)	 2N3494, 2N3496 2N3495, 2N3497	I_{CBO}	 — —	 100 100	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	25	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) ($I_C = 100\ \mu$Adc, $V_{CE} = 10$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 10$ Vdc)	 2N3494, 2N3496	h_{FE}	 35 40 40 40 35	 — — — — —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	 2N3494, 2N3496 2N3495, 2N3497	$V_{CE(sat)}$	 — —	 0.3 0.35	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)		$V_{BE(sat)}$	0.6	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 20$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	 2N3494, 2N3496 2N3495, 2N3497	f_T	 200 150	 — —	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	 2N3494, 2N3496 2N3495, 2N3497	C_{obo}	 — —	 7.0 6.0	pF
Input Capacitance ($V_{BE} = 2.0$ Vdc, $I_C = 0$, f = 100 kHz)		C_{ibo}	—	30	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	0.1	1.2	k ohms
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{re}	—	2.0	X 10^{-4}
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	40	300	—
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	—	300	μmhos
Real Part of Input Impedance (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 300 MHz)	$Re(h_{ie})$	—	30	Ohms
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 30 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_{on}	—	300	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	t_{off}	—	1000	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

4

FIGURE 1 – TURN-ON TIME TEST CIRCUIT

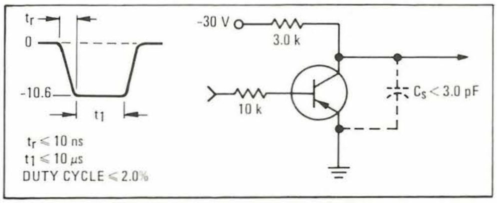


FIGURE 2 – TURN-OFF TIME TEST CIRCUIT

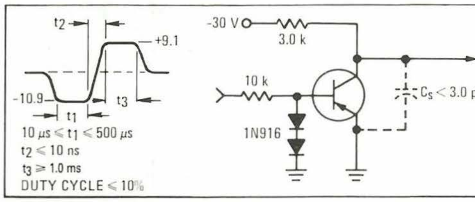


FIGURE 3 — V_{CE} (sat) versus I_C

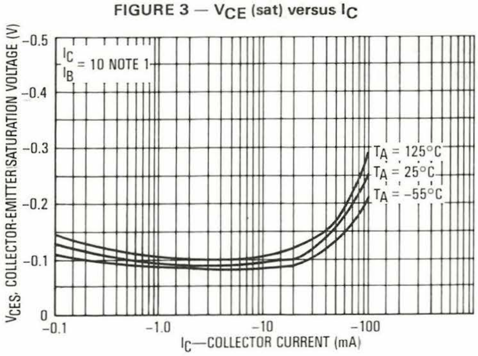


FIGURE 4 — I_{CBO} versus T_A

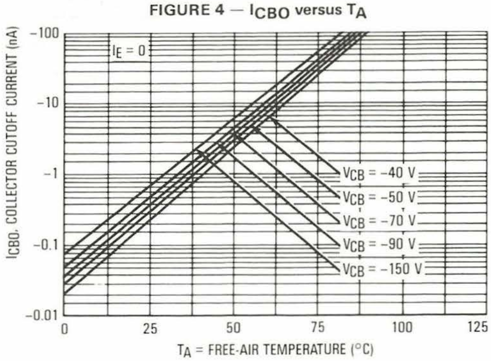


FIGURE 5 — h_{FE} versus I_C

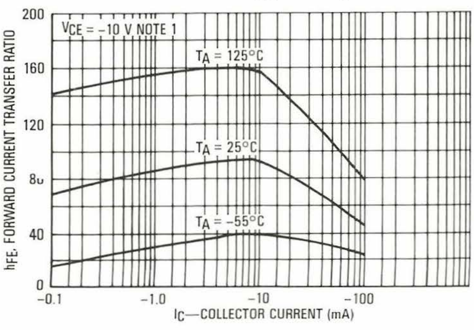


FIGURE 6 — V_{BE} versus I_C

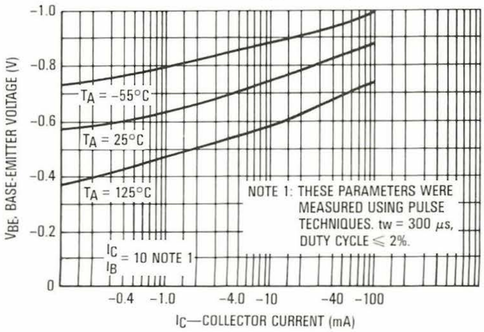


FIGURE 7 — f_T versus I_C

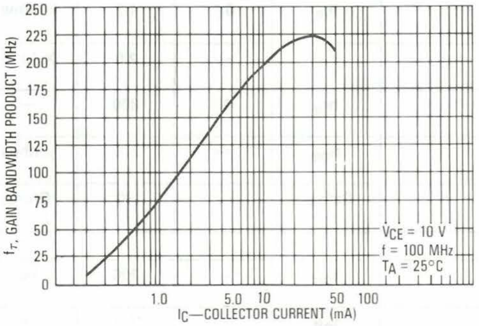


FIGURE 8 — C_{OBO} versus V_{CB}

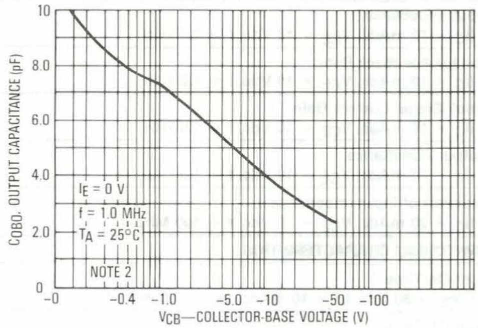
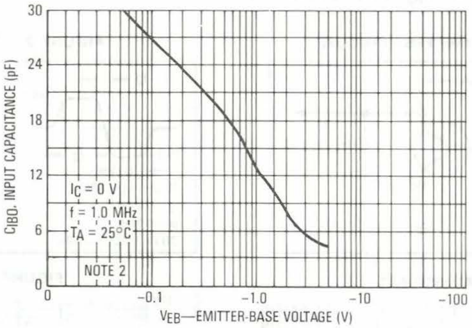


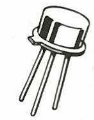
FIGURE 9 — C_{IBO} versus V_{EB}



NOTE 2: CAPACITANCE MEASURE MADE WITH TO-18 PACKAGE.

2N3498 thru 2N3501

JAN, JTX, JTXV AVAILABLE
CASE 79-02, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N3498 2N3499	2N3500 2N3501	Unit
Collector-Emitter Voltage	V_{CEO}	100	150	Vdc
Collector-Base Voltage	V_{CBO}	100	150	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	500	300	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1) ($I_C = 10$ mAdc, $I_B = 0$)	2N3498, 2N3499 2N3500, 2N3501	$V_{(BR)CEO}$	100 150	— —	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	2N3498, 2N3499 2N3500, 2N3501	$V_{(BR)CBO}$	100 150	— —	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	6.0	— —	— —	Vdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$) ($V_{CB} = 50$ Vdc, $I_E = 0$, $T_A = 150°C$) ($V_{CB} = 75$ Vdc, $I_E = 0$) ($V_{CB} = 75$ Vdc, $I_E = 0$, $T_A = 150°C$)	 2N3498, 2N3499 2N3500, 2N3501 	I_{CBO}	 — — — —	 — — — —	 0.050 50 0.050 50	μAdc
Emitter Cutoff Current ($V_{BE(off)} = 4.0$ Vdc, $I_C = 0$)		I_{EBO}	—	—	25	nAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				—
($I_C = 0.1$ mAdc, $V_{CE} = 10$ Vdc)	2N3498, 2N3500 2N3499, 2N3501		20 35	— —	— —	
($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc)	2N3498, 2N3500 2N3499, 2N3501		25 50	— —	— —	
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	2N3498, 2N3500 2N3499, 2N3501		35 75	— —	— —	
($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)	2N3498, 2N3500 2N3499, 2N3501		40 100	— —	120 300	
($I_C = 300$ mAdc, $V_{CE} = 10$ Vdc)	2N3500 2N3501		15 20	— —	— —	
($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc)	2N3498 2N3499		15 20	— —	— —	
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 300$ mAdc, $I_B = 30$ mAdc)	 All Types All Types 2N3500, 2N3501 2N3498, 2N3499	$V_{CE(sat)}$	 — — — —	 — — — —	 0.2 0.25 0.4 0.6	Vdc

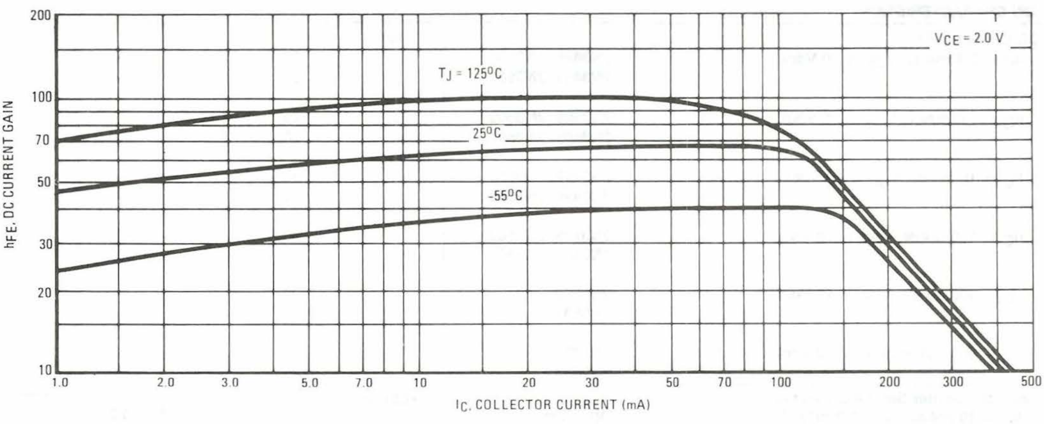
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	All Types		—	—	0.8	
(I_C = 50 mAdc, I_B = 5.0 mAdc)	All Types		—	—	0.9	
(I_C = 150 mAdc, I_B = 15 mAdc)	2N3500, 2N3501		—	—	1.2	
(I_C = 300 mAdc, I_B = 30 mAdc)	2N3498, 2N3499		—	—	1.4	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(2) (V_{CE} = 20 Vdc, I_C = 20 mAdc, f = 100 MHz)		f_T	150	—	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	2N3498, 2N3499 2N3500, 2N3501	C_{obo}	— —	— —	10 8.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	—	80	pF
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3498, 2N3500 2N3499, 2N3501	h_{ie}	0.2 0.25	— —	1.0 1.25	k ohms
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3498, 2N3500 2N3499, 2N3501	h_{re}	— —	— —	2.5 4.0	$X\ 10^{-4}$
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3498, 2N3500 2N3499, 2N3501	h_{fe}	50 75	— —	300 375	—
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3498, 2N3500 2N3499, 2N3501	h_{oe}	— —	— —	100 200	μmhos
SWITCHING CHARACTERISTICS						
Delay Time (I_C = 150 mAdc, I_{B1} = 15 mAdc, V_{CC} = 100 Vdc, $V_{BE(off)}$ = 2.0 Vdc)		t_d	—	20	—	ns
Rise Time (I_C = 150 mAdc, I_{B1} = 15 mAdc, V_{CC} = 100 Vdc, $V_{BE(off)}$ = 2.0 Vdc)		t_r	—	35	—	ns
Storage Time (I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc, V_{CC} = 100 Vdc)		t_s	—	800	—	ns
Fall Time (I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc, V_{CC} = 100 Vdc)		t_f	—	80	—	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$.

4

FIGURE 1 – CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE
2N3498



2N3499

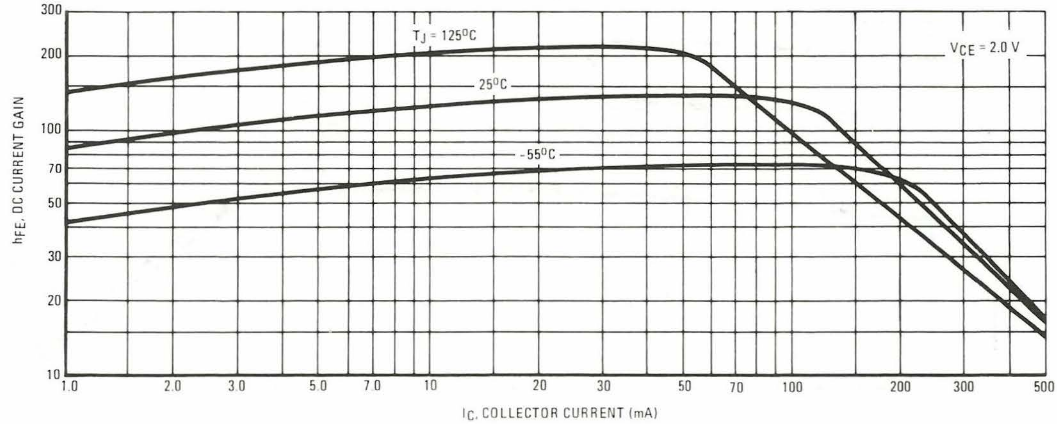


FIGURE 2 – CURRENT GAIN CHARACTERISTICS versus COLLECTOR-EMITTER VOLTAGE

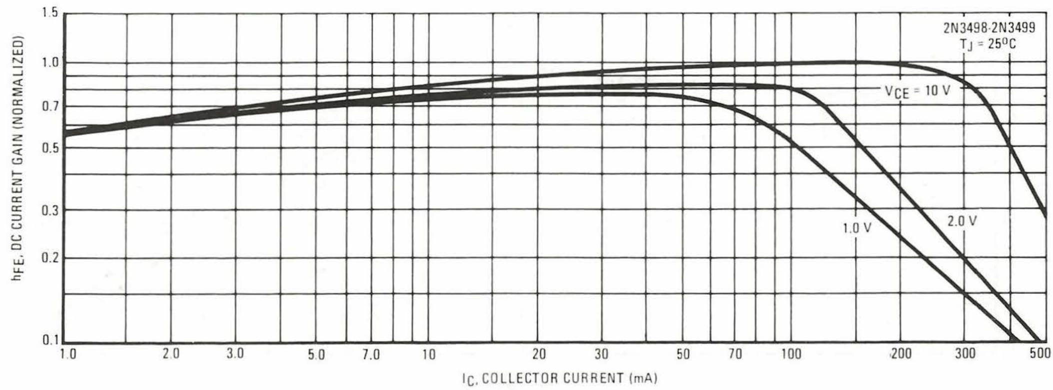
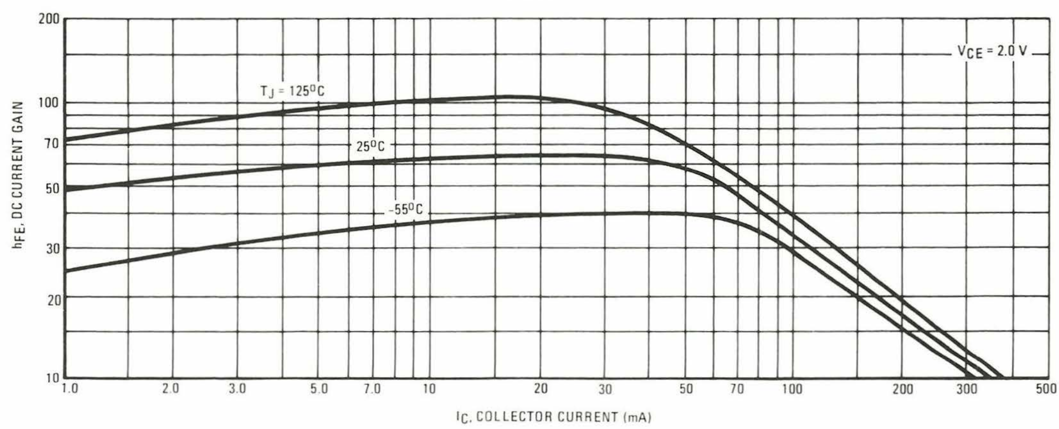


FIGURE 3 – CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE
2N3500



4

2N3501

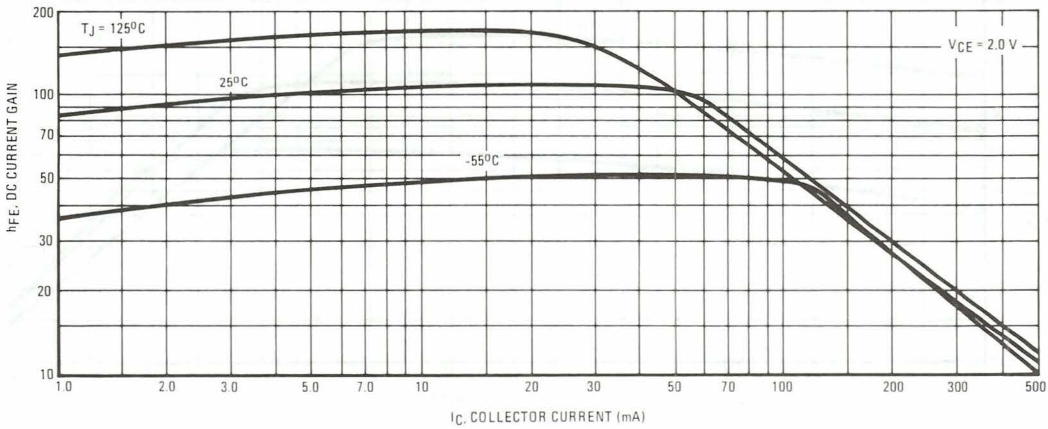


FIGURE 4 – CURRENT GAIN CHARACTERISTICS versus COLLECTOR-EMITTER VOLTAGE

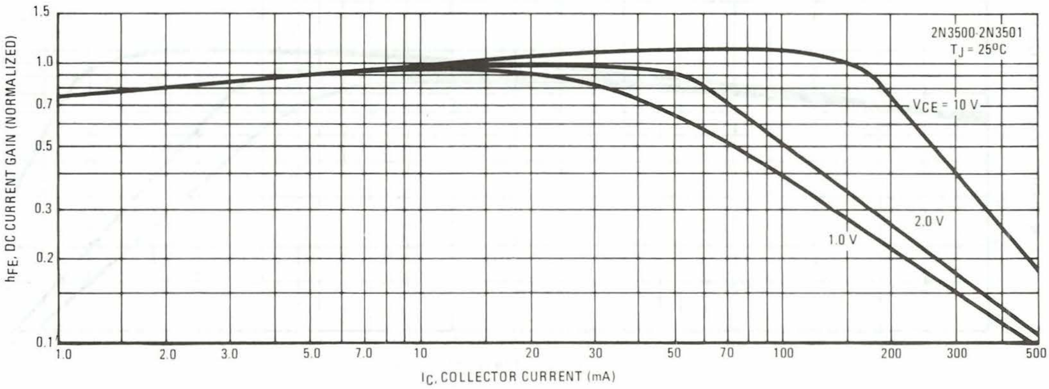


FIGURE 5 – "ON" VOLTAGES

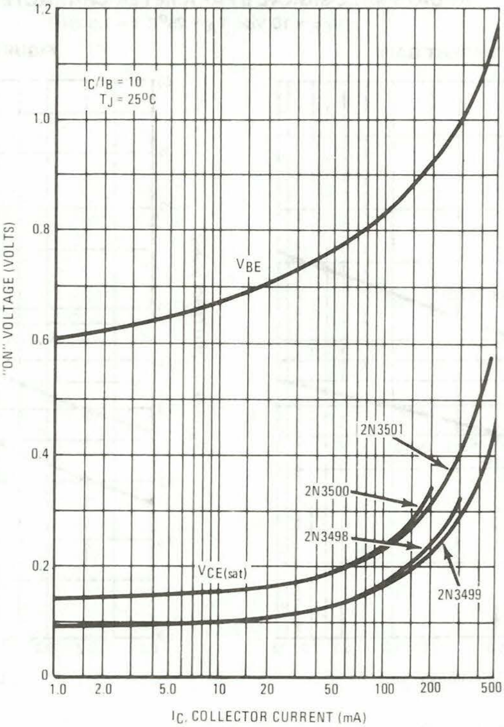


FIGURE 6 – TEMPERATURE COEFFICIENTS

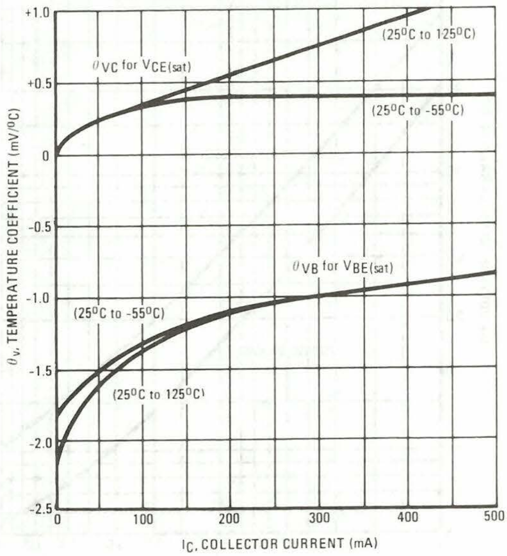
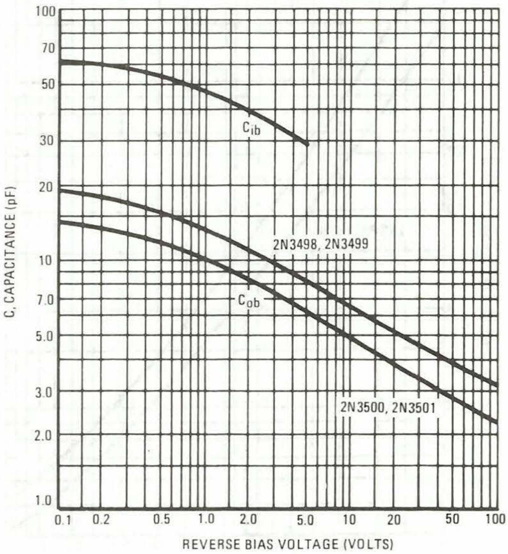


FIGURE 7 – CAPACITANCE



4

AUDIO SMALL-SIGNAL h PARAMETER CHARACTERISTICS

(V_{CE} = 10 Vdc, T_A = 25°C, f = 1.0 kHz)

FIGURE 8 – CURRENT GAIN

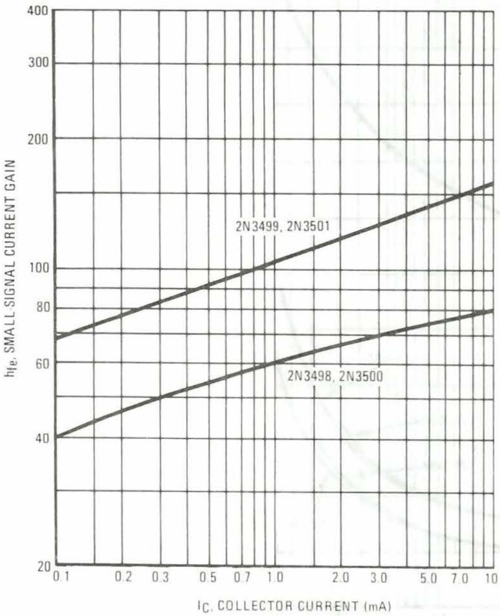


FIGURE 9 – OUTPUT IMPEDANCE

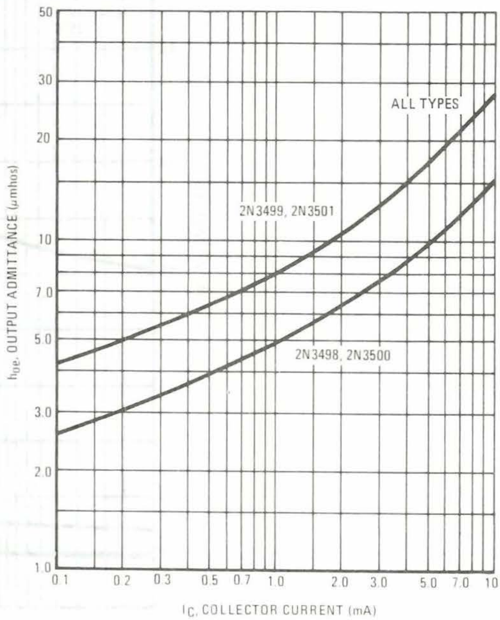


FIGURE 10 – INPUT IMPEDANCE

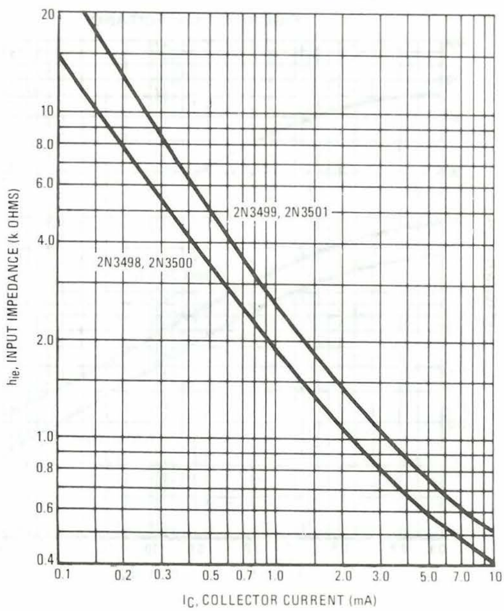
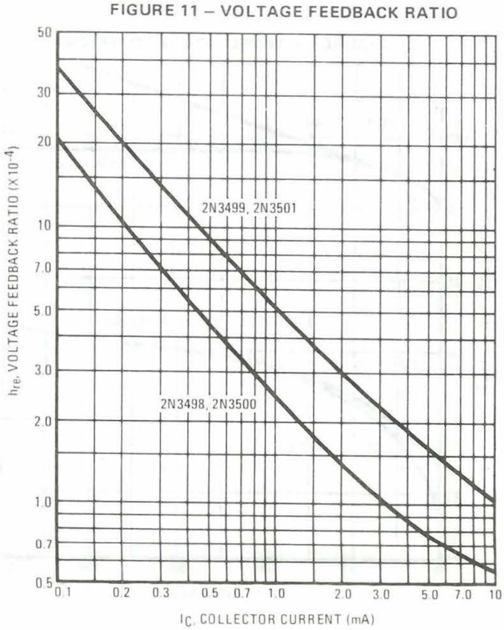
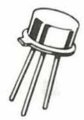


FIGURE 11 – VOLTAGE FEEDBACK RATIO



2N3506
2N3507

JAN, JTX, JTXV AVAILABLE
CASE 79, STYLE 1
TO-39 (TO-205AD)



SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N3506	2N3507	Unit
Collector-Emitter Voltage	V_{CEO}	40	50	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	3.0		Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.175	°C/mW
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	35	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, pulsed, $I_B = 0$)	2N3506 2N3507	$V_{(BR)CEO}$	40 50	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	2N3506 2N3507	$V_{(BR)CBO}$	60 80	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 40$ Vdc, $V_{EB(off)} = 4.0$ Vdc) ($V_{CE} = 40$ Vdc, $V_{EB(off)} = 4.0$ Vdc, $T_A = 100°C$) ($V_{CE} = 60$ Vdc, $V_{EB(off)} = 4.0$ Vdc) ($V_{CE} = 60$ Vdc, $V_{EB(off)} = 4.0$ Vdc, $T_A = 100°C$)	 2N3506 2N3507 	I_{CEX}	 — — — —	 1.0 150 1.0 150	μAdc
Base Cutoff Current ($V_{CE} = 40$ Vdc, $V_{EB(off)} = 4.0$ Vdc) ($V_{CE} = 60$ Vdc, $V_{EB(off)} = 4.0$ Vdc)	 2N3506 2N3507	I_{BL}	 — —	 1.0 1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) ($I_C = 500$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 1.5$ Adc, $V_{CE} = 2.0$ Vdc) ($I_C = 2.5$ Adc, $V_{CE} = 3.0$ Vdc) ($I_C = 3.0$ Adc, $V_{CE} = 5.0$ Vdc) 	 2N3506 2N3507 2N3506 2N3507 2N3506 2N3507 2N3506 2N3507	h_{FE}	 50 35 40 30 30 25 25 20	 — — 200 150 — — — —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 500$ mAdc, $I_B = 50$ mAdc) ($I_C = 1.5$ Adc, $I_B = 150$ mAdc) ($I_C = 2.5$ Adc, $I_B = 250$ mAdc)		$V_{CE(sat)}$	— — —	0.5 1.0 1.5	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 500$ mAdc, $I_B = 50$ mAdc) ($I_C = 1.5$ Adc, $I_B = 150$ mAdc) ($I_C = 2.5$ Adc, $I_B = 250$ mAdc)		$V_{BE(sat)}$	— 0.9 —	1.0 1.4 2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 100$ mAdc, $V_{CE} = 5$ Vdc, f = 20 MHz)		f_T	60	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)		C_{obo}	—	40	pF
Input Capacitance ($V_{BE} = 3$ Vdc, $I_C = 0$, f = 100 kHz)		C_{ibo}	—	300	pF

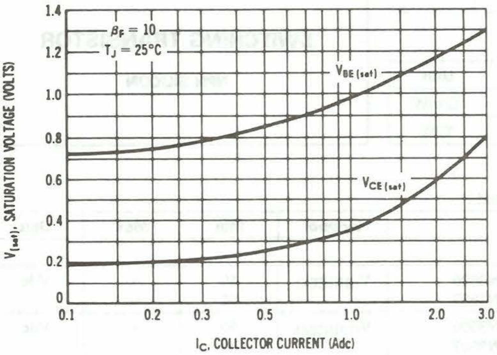
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS					
Delay Time	I_C = 1.5 Adc, I_{B1} = 150 mAdc	t_d	—	15	ns
Rise Time	V_{CC} = 30 V, V_{EB} = 0 V	t_r	—	30	ns
Storage Time	I_C = 1.5 Adc, I_{B1} = I_{B2} = 150 mAdc	t_s	—	55	ns
Fall Time	V_{CC} = 30 V	t_f	—	35	ns

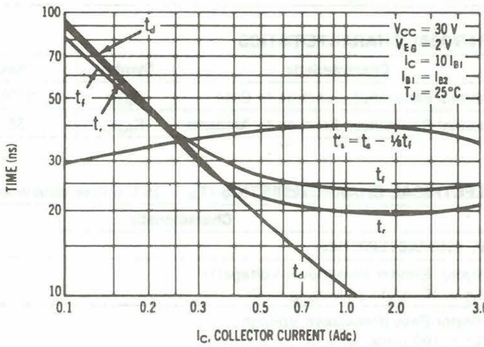
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.

4

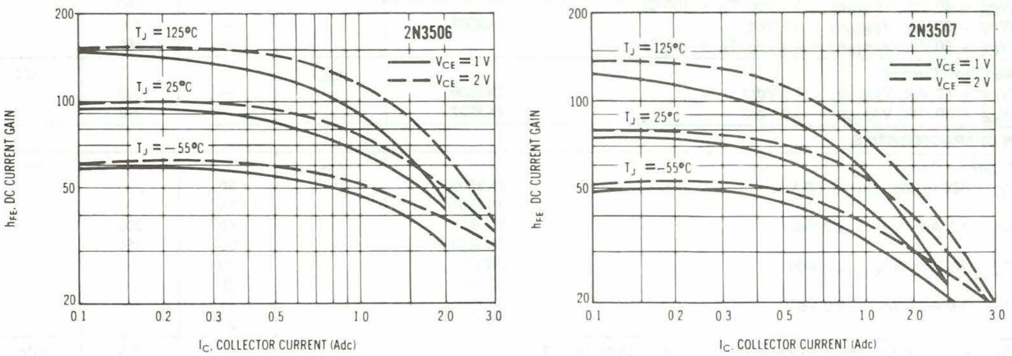
SATURATION VOLTAGES



SWITCHING TIMES



CURRENT GAIN CHARACTERISTICS



2N3508
2N3509

CASE 26, STYLE 1
TO-46 (TO-206AB)

SWITCHING TRANSISTOR

NPN SILICON

Refer to 2N2368 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current (10 μs pulse) (Peak)	I_C	500	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.40 2.29	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.0 11.43	Watts mW/°C
Operating and Storage Temperature Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.0875	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.438	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_B = 0)		$V_{(BR)CBO}$	40	—	Vdc
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc)		$V_{(BR)CEO}$	20	—	Vdc
Collector-Emitter Voltage (I_C = 10 μAdc, I_B = 0)		$V_{(BR)CES}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, $V_{EB(off)}$ = 3.0 Vdc)		I_{CEX}	—	0.2	μAdc
Collector Cutoff Current (V_{CB} = 20 Vdc) (V_{CB} = 20 Vdc, T_A = 150°C)	 Both Types 2N3508 2N3509	I_{CBO}	 — — —	 0.2 30 50	μAdc
Base Cutoff Current (V_{CE} = 20 Vdc, $V_{EB(off)}$ = 3.0 Vdc)		I_{BL}	—	0.5	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	 2N3508 2N3509	h_{FE}	 40 100	 120 300	—
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C)	2N3508 2N3509		20 40	— —	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	2N3508 2N3509		20 30	— —	
Collector-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{CE(sat)}$	 — —	 0.25 0.45	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{BE(sat)}$	 0.70 0.8	 0.85 1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)		C_{obo}	—	4.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

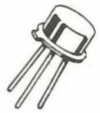
Characteristic		Symbol	Min	Max	Unit
Input Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 140 kHz)		C_{ibo}	—	4.0	pF
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		h_{fe}	5.0	—	—
SWITCHING CHARACTERISTICS					
Storage Time (I_C = I_{B1} = I_{B2} = 10 mA)		$t_s(\tau_s)$	—	13	ns
Turn-On Time (I_C = 10 mA, I_{B1} = 3.0 mA, V_{CC} = 3.0 V, V_{OB} = 1.5 V)		t_{on}	—	12	ns
Turn-Off Time (I_C = 10 mA, I_{B1} = 3.0 mA, I_{B2} = 1.5 mA, V_{CC} = 3.0 V)		t_{off}	—	18	ns
Total Control Charge (I_C = 10 mA, I_B = 1.0 mA, V_{CC} = 3.0 V)		Q_T	—	50	pC
Delay Time	V_{CC} = 10 V, V_{EB} = 2.0 V, I_C = 100 mA, I_{B1} = 10 mA	t_d	—	5.0	ns
Rise Time		t_r	—	18	ns
Storage Time	V_{CC} = 10 V I_C = 100 mA, I_{B1} = I_{B2} = 10 mA	t_s	—	13	ns
Fall Time		t_f	—	15	ns

(1) Pulse Test: PW = 300 μs, Duty Cycle ≤ 2.0%.

4

2N3510
2N3511

CASE 27, STYLE 1
TO-52 (TO-206AC)



2N3647
2N3648

CASE 26, STYLE 1
TO-46 (TO-206AB)

SWITCHING TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N3510 2N3647	2N3511 2N3648	Unit
Collector-Emitter Voltage	V_{CEO}	10	15	Vdc
Collector-Base Voltage	V_{CBO}	40	40	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		TO-46 2N3647 2N3648	**TO-52 2N3510 2N3511**	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	400 2.28	360 2.06	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.0 11.43	1.2 6.9	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

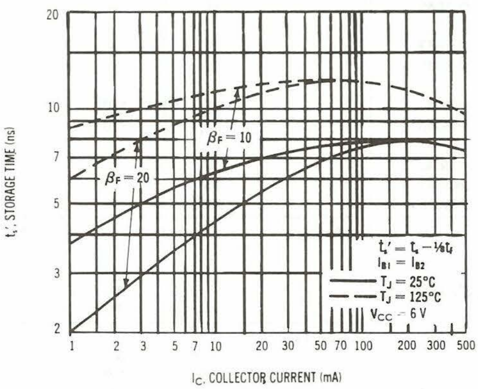
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	 2N3510, 2N3647 2N3511, 2N3648	$V_{(BR)CEO}$	 10 15	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)		$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 10$ Vdc, $V_{EB(off)} = 1.0$ Vdc) ($V_{CE} = 10$ Vdc, $V_{EB(off)} = 1.0$ Vdc, $T_A = 150°C$)		I_{CEX}	 — —	 .025 50	μAdc
Base Cutoff Current ($V_{CE} = 10$ Vdc, $V_{OB} = 1.0$ Vdc)		I_{BL}	—	.025	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 1.0$ Vdc, TA = −55°C) ($I_C = 300$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 500$ mAdc, $V_{CE} = 1.0$ Vdc)	 2N3510, 2N3647 2N3511, 2N3648 2N3510, 2N3647 2N3511, 2N3648 2N3510, 2N3647 2N3511, 2N3648 2N3511, 2N3648 2N3510, 2N3647 2N3511, 2N3648	h_{FE}	 12 15 20 25 25 30 12 15 12	 — — — — 150 120 — — —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 300$ mAdc, $I_B = 30$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)	 2N3510, 2N3647 2N3511, 2N3648	$V_{CE(sat)}$	 — — — —	 0.25 0.4 0.6 0.8	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 300$ mAdc, $I_B = 30$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)	 2N3510, 2N3647 2N3511, 2N3648	$V_{BE(sat)}$	 — 0.8 — —	 0.8 1.0 1.15 1.5	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

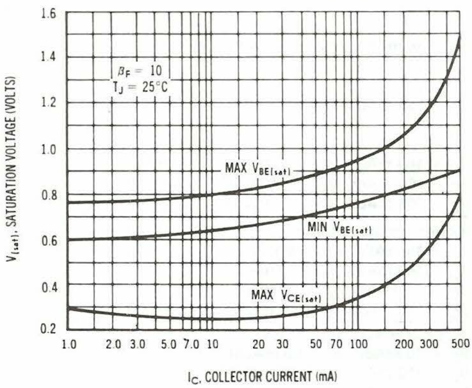
Characteristic			Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS						
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)			C_{obo}	—	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)			C_{ibo}	—	8.0	pF
Input Impedance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)			h_{ie}	0.6	4.5	kohms
Voltage Feedback Ratio (I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)			h_{re}	—	25	$X\ 10^{-4}$
Small-Signal Current Gain			h_{fe}			—
(I_C = 15 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		2N3510, 2N3647		3.5	—	
		2N3511, 2N3648		4.5	—	
(I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)				20	150	
Output Admittance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)			h_{oe}	10	100	μmhos
SWITCHING CHARACTERISTICS						
Delay Time	(I_C = 150 mA, I_{B1} = 15 mA, V_{EB} = 0.5 V, V_{CC} = 6.0 V)	2N3510, 2N3647	t_d	—	10	ns
		2N3511, 2N3648		—	8.0	
Rise Time		2N3510, 2N3647	t_r	—	12	ns
		2N3511, 2N3648		—	10	
Storage Time	(I_C = 150 mA, I_{B1} = $-I_{B2}$ = 15 mA, V_{CC} = 6.0 V)	2N3510, 2N3647	t_s	—	16	ns
		2N3511, 2N3648		—	12	
Fall Time		2N3510, 2N3647	t_f	—	12	ns
		2N3511, 2N3648		—	8.0	
Turn-On Time	(I_C = 150 mA, I_{B1} = 15 mA, V_{EB} = 0.5 V, V_{CC} = 6.0 V)	2N3510, 2N3647	t_{on}	—	20	ns
		2N3511, 2N3648		—	16	
Turn-Off Time	(I_C = 150 mA, I_{B1} = $-I_{B2}$ = 15 mA, V_{CC} = 6.0 V)	2N3510, 2N3647	t_{off}	—	25	ns
		2N3511, 2N3648		—	18	
Total Control Charge (I_C = 150 mA, I_B = 15 mA, V_{CC} = 6.0 V)			Q_T	—	300	pC

(1) Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2.0%.

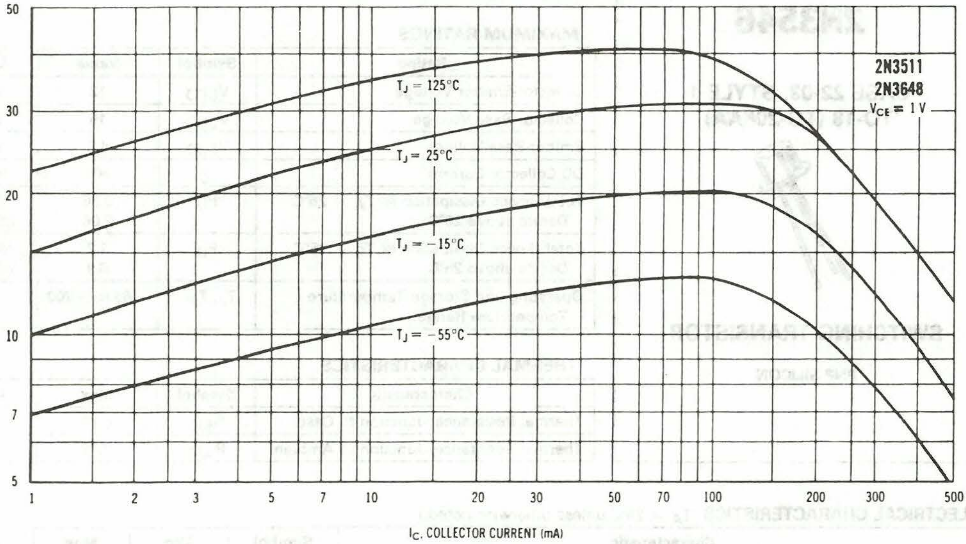
STORAGE TIME VARIATION

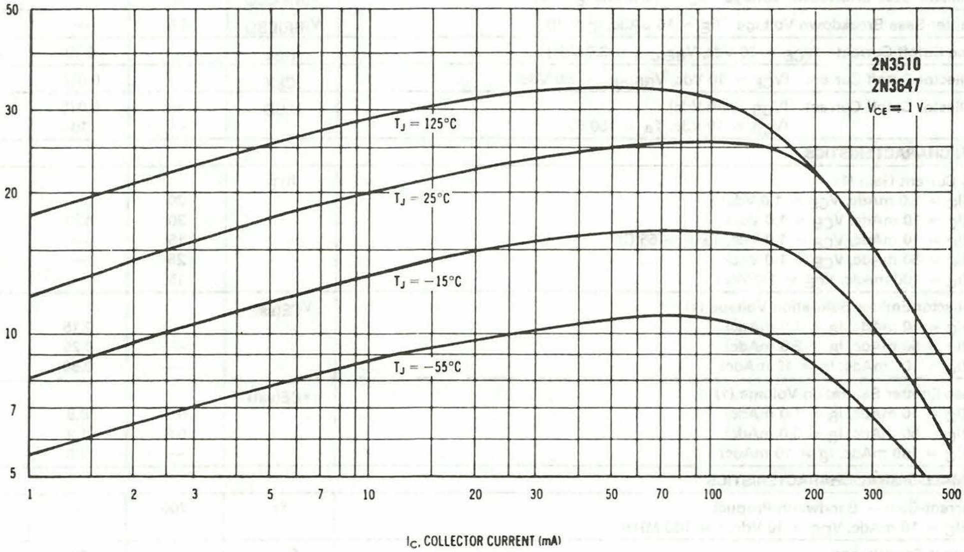


LIMITS OF SATURATION VOLTAGE



MINIMUM CURRENT GAIN CHARACTERISTICS





2N3546

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	15	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	Vdc
DC Collector Current	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.2 6.9	Watts mW/°C
Operating and Storage Temperature Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.15	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.49	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	12	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	15	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.5	—	Vdc
Base Cutoff Current ($V_{CE} = 10$ Vdc, $V_{BE(off)} = 3.0$ Vdc)	I_{BEV}	—	0.10	μAdc
Collector Cutoff Current ($V_{CE} = 10$ Vdc, $V_{BE(off)} = 3.0$ Vdc)	I_{CEX}	—	0.010	μAdc
Collector Cutoff Current ($V_{CB} = 10$ Vdc) ($V_{CB} = 10$ Vdc, $T_A = 150°C$)	I_{CBO}	— —	0.010 10	μAdc
ON CHARACTERISTICS				
DC Current Gain (1) ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc, $T_A = -55°C$) ($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	 20 30 15 25 15	 — 120 — — —	—
Collector-Emitter Saturation Voltage (1) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc) ($I_C = 100$ mAdc, $I_B = 10$ mAdc)	$V_{CE(sat)}$	 — — —	 0.15 0.25 0.50	Vdc
Base-Emitter Saturation Voltage (1) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc) ($I_C = 100$ mAdc, $I_B = 10$ mAdc)	$V_{BE(sat)}$	 0.7 0.8 —	 0.9 1.3 1.6	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	700	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	6.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)	C_{ibo}	—	5.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS					
Delay Time	I_C = 50 mA, I_{B1} = 5 .0 mA V_{BE} = 2.0 V, V_{CC} = 3.0 V	t_d	—	10	ns
Rise Time		t_r	—	15	ns
Storage Time	I_C = 50 mA, I_{B1} = I_{B2} = 5.0 mA V_{CC} = 3.0 V	t_s	—	20	ns
Fall Time		t_f	—	15	ns
Turn-On Time		t_{on}	—	40	ns
Turn-Off Time		t_{off}	—	30	ns
Total Control Charge (I_C = 50 mA, I_B = 5.0 mA, V_{CC} = 3.0 V)		Q_T	—	400	pC

(1) Pulse Test: PW = 300 μs, Duty Cycle ≤ 2.0%.

4

FIGURE 1

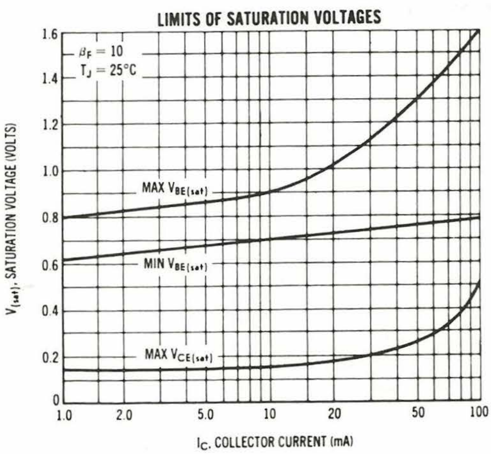


FIGURE 2

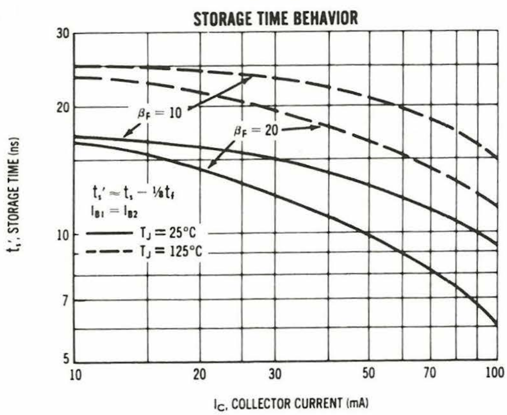
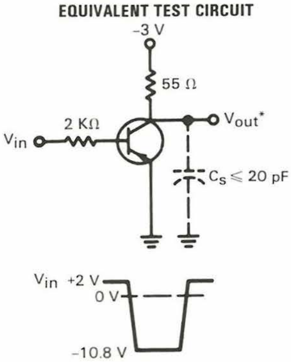


FIGURE 3

DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

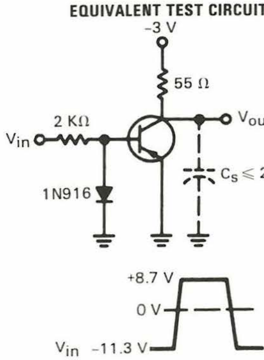


PULSE WIDTH = 200 ns
RISE TIME ≤ 2 ns
DUTY CYCLE ≤ 10%

*OSCILLOSCOPE RISE TIME ≤ 1 ns

FIGURE 4

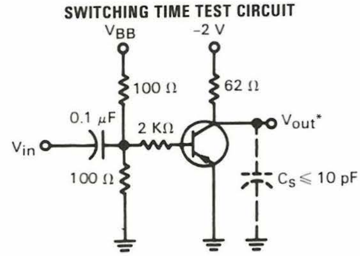
STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



PULSE WIDTH = 200 ns
RISE TIME ≤ 2 ns
DUTY CYCLE ≤ 10%

FIGURE 5

SWITCHING TIME TEST CIRCUIT



PULSE WIDTH > 200 ns
RISE TIME < 2 ns
Z_{in} = 50 Ω

t_{on}: V_{BB} = +3 V, V_{in} = -7 V
t_{off}: V_{BB} = -4 V, V_{in} = +6 V

FIGURE 6
MINIMUM CURRENT GAIN CHARACTERISTICS

2N3634 thru 2N3637

JAN, JTX AVAILABLE
CASE 79, STYLE 1
TO-39 (TO-39-205AD)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N3634 2N3635	2N3636 2N3637	Unit
Collector-Emitter Voltage	V_{CEO}	140	175	Vdc
Collector-Base Voltage	V_{CBO}	140	175	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	2N3634, 2N3635 2N3636, 2N3637	$V_{(BR)CEO}$	140 175	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	2N3634, 2N3635 2N3636, 2N3637	$V_{(BR)CBO}$	140 175	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 100$ Vdc, $I_E = 0$)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) ($I_C = 0.1$ mAdc, $V_{CE} = 10$ Vdc)	2N3634, 2N3636 2N3635, 2N3637	h_{FE}	40 80	— —	—
($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc)	2N3634, 2N3636 2N3635, 2N3637		45 90	— —	
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	2N3634, 2N3636 2N3635, 2N3637		50 100	— —	
($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc)	2N3634, 2N3636 2N3635, 2N3637		50 100	150 300	
($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)	2N3634, 2N3636 2N3635, 2N3637		25 50	— —	
Collector-Emitter Saturation Voltage(1) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{CE(sat)}$	— —	0.3 0.5	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{BE(sat)}$	— 0.65	0.8 0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($V_{CE} = 30$ Vdc, $I_C = 30$ mAdc, f = 100 MHz)	2N3634, 2N3636 2N3635, 2N3637	f_T	150 200	— —	MHz

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	10	pF
Input Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	75	pF
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3634, 2N3636 2N3635, 2N3637	h_{ie}	100 200	600 1200	ohms
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{re}	—	3.0	X 10^{-4}
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3634, 2N3636 2N3635, 2N3637	h_{fe}	40 80	160 320	—
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	—	200	μmhos
Noise Figure (I_C = 0.5 mAdc, V_{CE} = 10 Vdc, R_S = 1.0 k ohms, f = 1.0 kHz)		NF	—	3.0	dB

SWITCHING CHARACTERISTICS

		Symbol	Min	Max	Unit
Turn-On Time	(V_{CC} = 100 Vdc, V_{BE} = 4.0 Vdc, I_C = 50 mAdc, I_{B1} = I_{B2} = 5.0 mAdc)	t_{on}	—	400	ns
Turn-Off Time		t_{off}	—	600	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — JUNCTION CAPACITANCE VARIATIONS

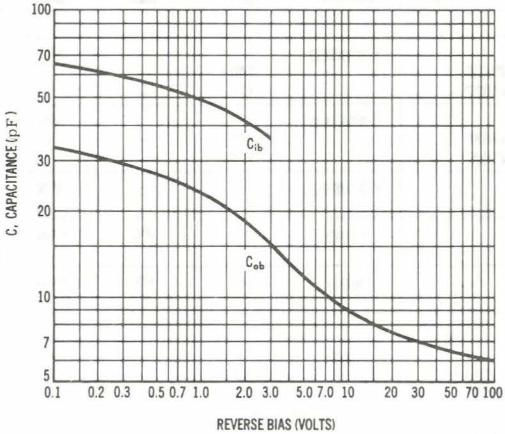


FIGURE 2 — GAIN-BANDWIDTH PRODUCT

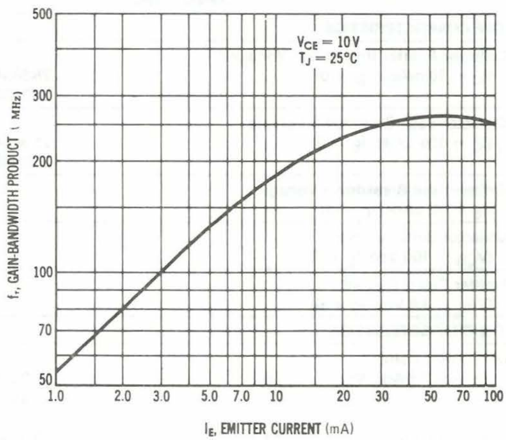
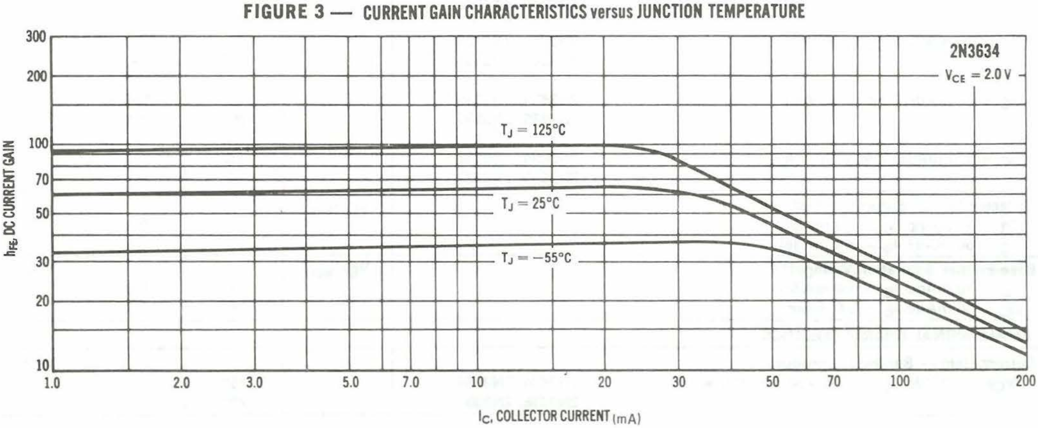


FIGURE 3 — CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE



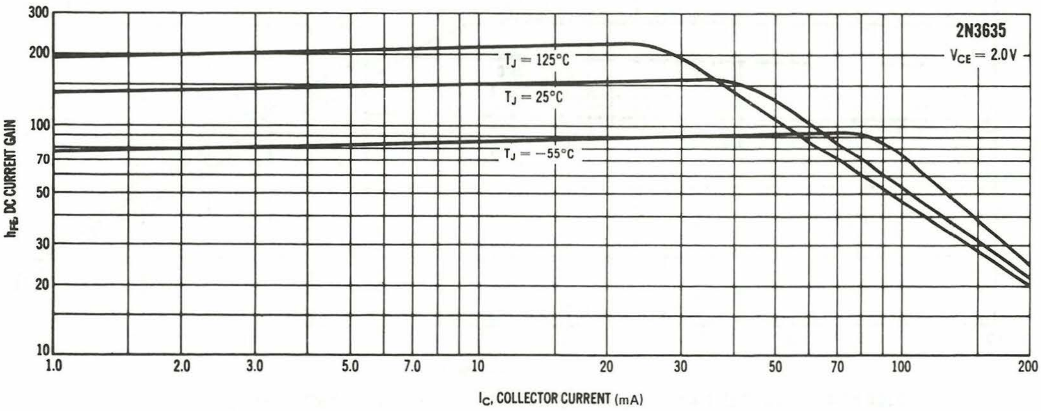


FIGURE 4 — CURRENT GAIN CHARACTERISTICS versus COLLECTOR EMITTER VOLTAGE

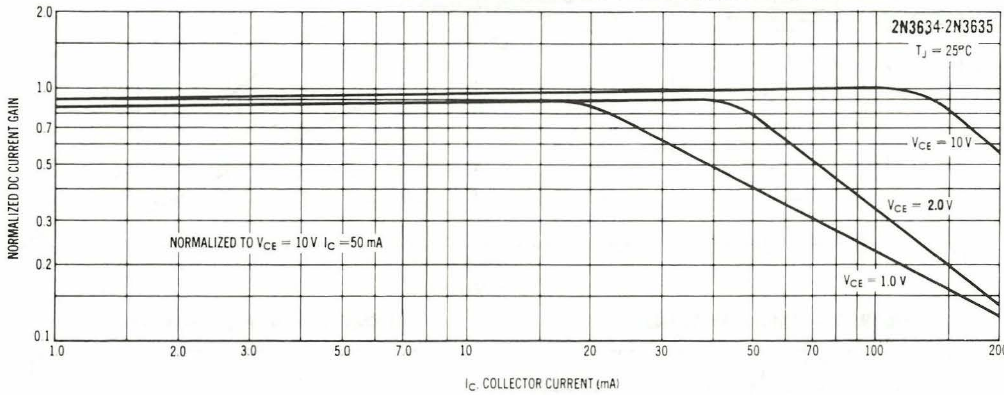
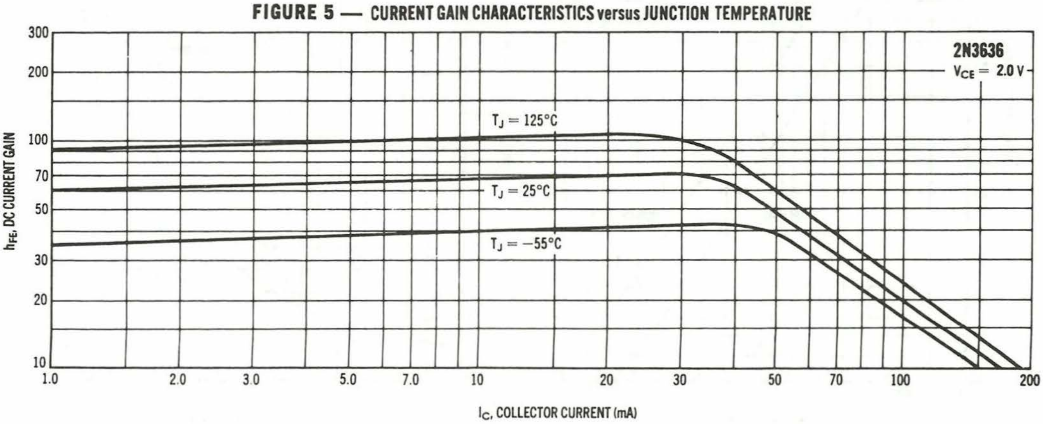


FIGURE 5 — CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE



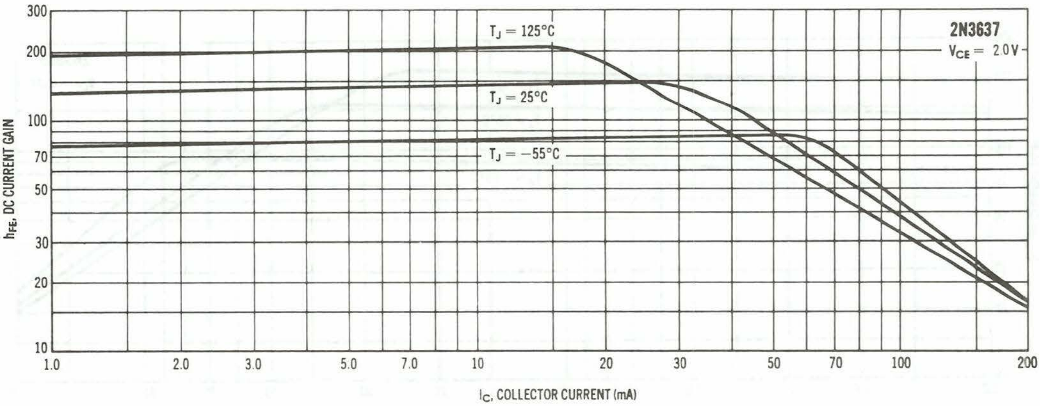


FIGURE 6 — CURRENT GAIN CHARACTERISTICS versus COLLECTOR EMITTER VOLTAGE

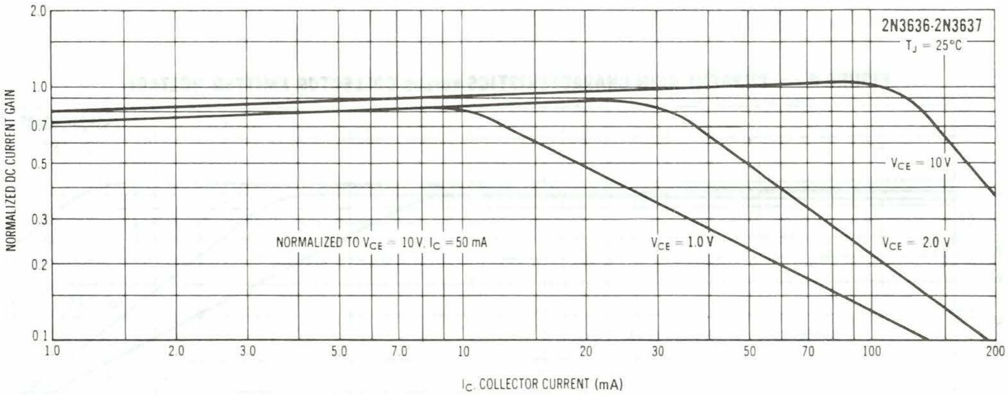


FIGURE 7 — INPUT IMPEDANCE

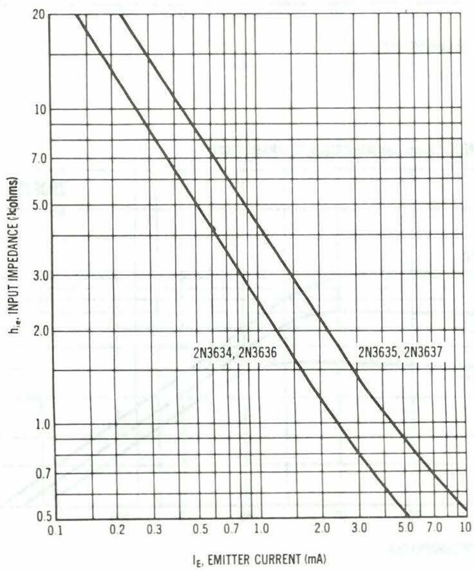
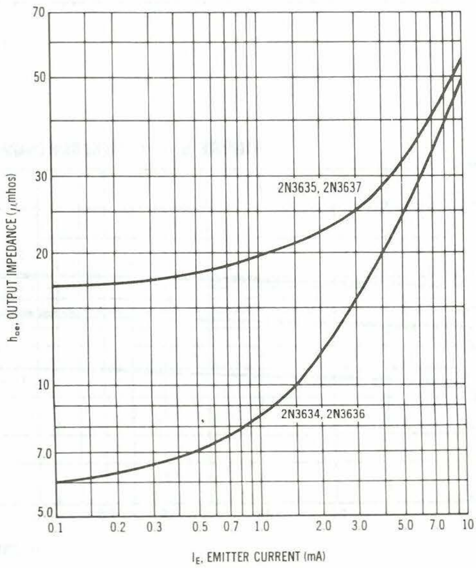


FIGURE 8 — OUTPUT IMPEDANCE



4

FIGURE 9 — CURRENT GAIN

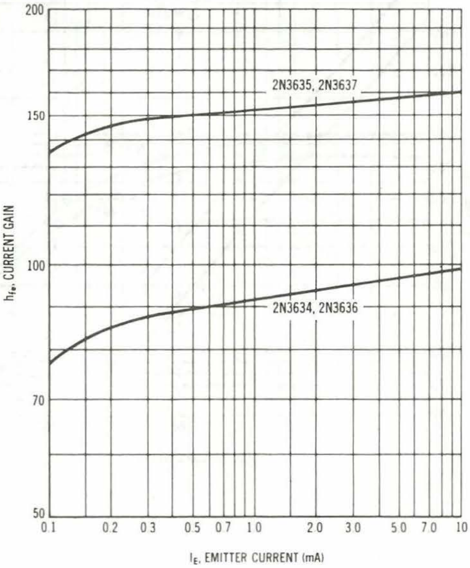


FIGURE 10 — VOLTAGE FEEDBACK RATIO

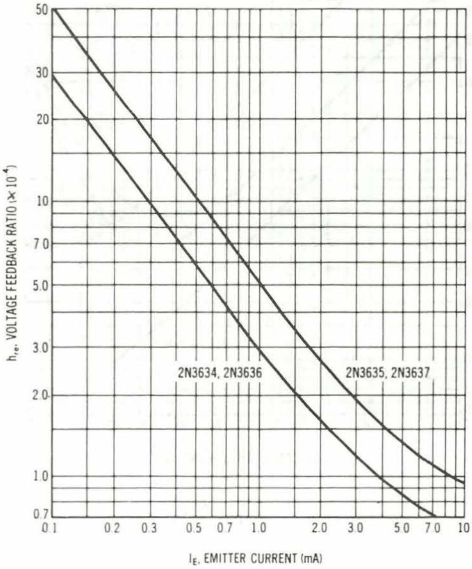


FIGURE 11 — SATURATION VOLTAGES

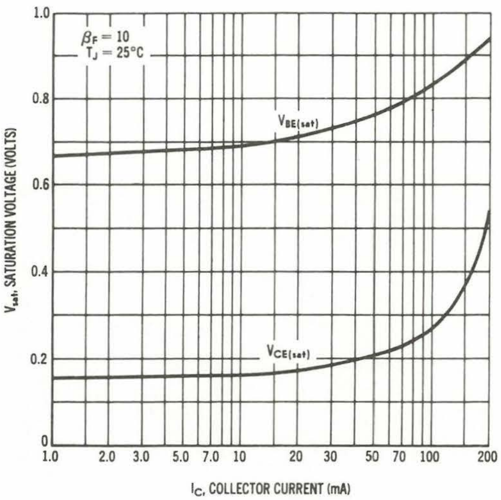


FIGURE 12 — TEMPERATURE COEFFICIENTS

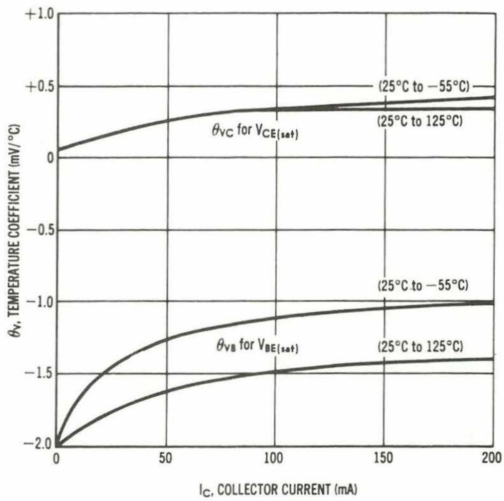
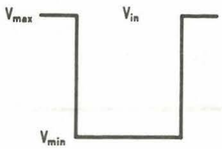


FIGURE 13 — SWITCHING TIME TEST CIRCUIT



P.W. ≅ 20 μs
DUTY CYCLE ≦ 2%
RISE TIME ≦ 20 ns

	V_{max}	V_{min}
TURN-ON	+4.0 V	−5.65 V
TURN-OFF	+4.1 V	−5.9 V

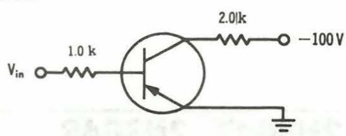


FIGURE 14 — TURN-ON TIME VARIATIONS WITH VOLTAGE

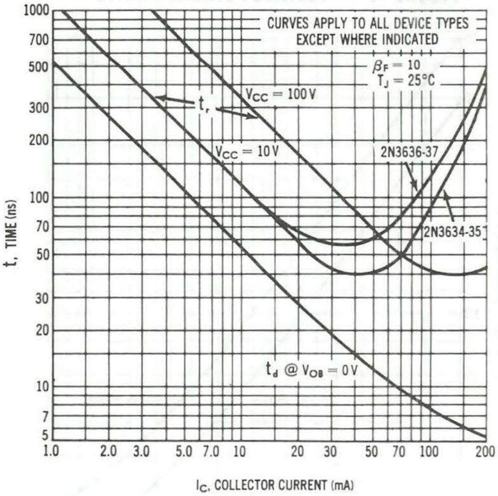
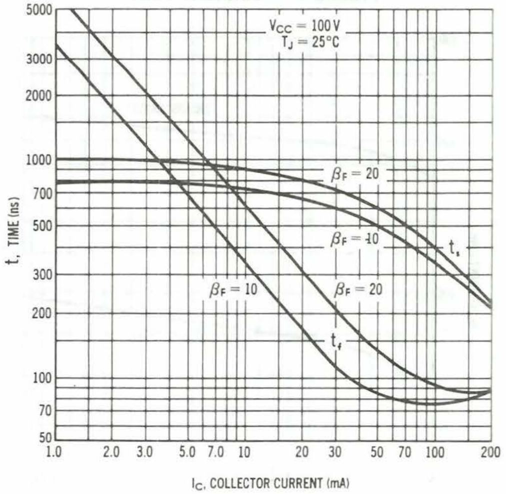


FIGURE 15 — TURN-OFF TIME VARIATIONS WITH CIRCUIT GAIN*



2N3647, 2N3648

For Specifications, See 2N3510 Data.

2N3677

CASE 26-03, STYLE 1
TO-46 (TO-206AB)

LOW POWER CHOPPER TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	20	V
Collector-Base Voltage	V_{CBO}	30	V
Emitter-Base Voltage	V_{EBO}	30	V
Collector Current — Continuous	I_C	100	mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	400 2.3	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

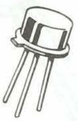
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Emitter-Collector Breakdown Voltage ($I_C = 1.0$ nA)	$V_{(BR)ECS}$	20	—	V
Collector-Base Breakdown Voltage ($I_C = 1.0$ mA)	$V_{(BR)CBO}$	30	—	V
Emitter-Base Breakdown Voltage ($I_E = 1.0$ mA)	$V_{(BR)EBO}$	30	—	V
Collector Cutoff Current ($V_{CB} = 30$ V)	I_{CBO}	—	1.0	nA
Emitter Cutoff Current ($V_{EB} = 30$ V)	I_{EBO}	—	1.0	nA
ON CHARACTERISTICS				
Offset Voltage ($I_B = 1.0$ mA)	$V_{EC(ofs)}$	—	1.0	mV
Common-Collector static forward transfer ratio ($I_E = 1.0$ mA, $V_{EC} = 6.0$ V)	h_{fe}	4.0	—	—
On series resistance ($I_B = 1.0$ mA)	r_s	0.1	8.0	ohms
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 6.0$ V, f = 159 kHz)	C_{obo}	—	10	pF
Input Capacitance ($V_{EB} = 6.0$ V, f = 159 kHz)	C_{ibo}	—	6.0	pF
Magnitude of Forward Current Transfer Ratio, Common-Emitter ($I_C = 1.0$ mA, $V_{CE} = 6.0$ V, f = 1.0 MHz)	$\|h_{fe}\|$	5.0	—	—

4

2N3712

CASE 79, STYLE 1
TO-39 (205AD)



AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N3498 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	150	Vdc
Collector-Base Voltage	V_{CBO}	150	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 30 mAdc, I_B = 0)	$V_{(BR)CEO}$	150	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	150	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 75 Vdc, I_E = 0) (V_{CB} = 75 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 — —	 0.1 50	μAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 25 30	 — 150	—
Collector-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	—	2.0	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 30 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	40	240	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	1.0	9.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	80	pF
Small-Signal Current Gain (I_C = 30 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	25	—	—
Collector Base Time Constant (I_E = 30 mAdc, V_{CB} = 10 Vdc, f = 31.9 MHz)	$rb'C_e$	—	100	ps

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N3724
2N3725

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N3724	2N3725	Unit
Collector-Emitter Voltage	V_{CEO}	30	50	Vdc
Collector-Base Voltage	V_{CBO}	50	80	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71		Watts mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	 2N3725 2N3724	$V_{(BR)CEO}$	 50 30	 — —	 — —	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10$ μAdc, $V_{BE} = 0$)	 2N3725 2N3724	$V_{(BR)CES}$	 80 50	 — —	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	 2N3725 2N3724	$V_{(BR)CBO}$	 80 50	 — —	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 40$ Vdc, $I_E = 0$) ($V_{CB} = 60$ Vdc, $I_E = 0$, $T_A = 100°C$) ($V_{CB} = 60$ Vdc, $I_E = 0$, $T_A = 100°C$)	 2N3725 2N3724 2N3725 2N3724	I_{CBO}	 — — — —	 0.12 0.12 — —	 1.7 1.7 120 120	μAdc
Collector Cutoff Current ($V_{CE} = 80$ Vdc, $V_{EB} = 0$) ($V_{CE} = 50$ Vdc, $V_{EB} = 0$)	 2N3725 2N3724	I_{CES}	 — —	 0.15 0.15	 10 10	μAdc
Base Current ($V_{CE} = 50$ V, $V_{EB} = 0$) ($V_{CE} = 80$ V, $V_{EB} = 0$)	 2N3724 2N3725	I_B	—	—	10	μAdc
ON CHARACTERISTICS(1)						
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc, $T_A = -55°C$) ($I_C = 300$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 500$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 500$ mAdc, $V_{CE} = 1.0$ Vdc, $T_A = -55°C$) ($I_C = 800$ mAdc, $V_{CE} = 2.0$ Vdc) ($I_C = 1.0$ Adc, $V_{CE} = 5.0$ Vdc) ($I_C = 800$ mA, $V_{CE} = 2.0$ V) ($I_C = 1.0$ Adc, $V_{CE} = 5.0$ V)	 2N3725 2N3725	h_{FE}	 30 60 30 40 35 20 25 30 20 25	 — — — — — — — — — —	 — 150 — — — — — — — —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	 2N3725 2N3724	$V_{BE(sat)}$	— —	 0.17 0.17	 0.25 0.25	Vdc

4

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

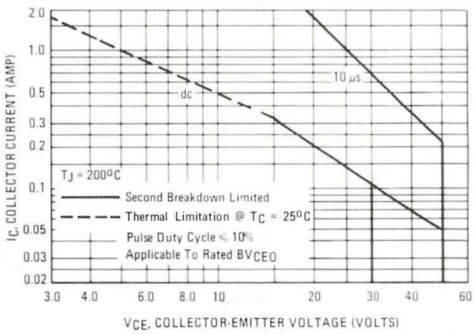
Characteristic		Symbol	Min	Typ	Max	Unit
			—			
(I_C = 100 mAdc, I_B = 10 mAdc)	2N3725		—	0.19	0.26	
	2N3724			0.19	0.20	
			—			
(I_C = 300 mAdc, I_B = 30 mAdc)	2N3725		—	0.25	0.40	
	2N3724			0.25	0.32	
			—			
(I_C = 500 mAdc, I_B = 50 mAdc)	2N3725		—	0.30	0.52	
	2N3724			0.30	0.42	
			—			
(I_C = 800 mAdc, I_B = 80 mAdc)	2N3725		—	0.43	0.80	
	2N3724			0.43	0.65	
			—			
(I_C = 1.0 mAdc, I_B = 100 mAdc)	2N3725		—	0.55	0.95	
	2N3724			0.55	0.75	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			—	—	0.76	
(I_C = 100 mAdc, I_B = 10 mAdc)			—	—	0.86	
(I_C = 300 mAdc, I_B = 30 mAdc)			—	—	1.1	
(I_C = 500 mAdc, I_B = 50 mAdc)			0.8	—	1.1	
(I_C = 800 mAdc, I_B = 80 mAdc)			—	—	1.5	
(I_C = 1.0 Adc, I_B = 100 mAdc)			—	—	1.7	
SMALL SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(2) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	300	—	—	MHz
Output Capacitance		C_{obo}				pF
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	2N3725		—	—	10	
	2N3724		—	—	12	
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	—	55	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 1.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$.

SWITCHING CHARACTERISTICS

Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 3.8 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc) (Figures 8, 10)	t_d	–	5.0	10	ns
Rise Time		t_r	–	15	30	ns
Turn-On Time		t_{on}	–	20	35	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 500 mAdc, $I_{B1} = I_{B2}$ = 50 mAdc) (Figures 9, 10)	t_s	–	35	50	ns
Fall Time		t_f	–	20	25	ns
Turn-Off Time		t_{off}	–	50	60	ns

FIGURE 1 — ACTIVE-REGION SAFE OPERATING AREA



TYPICAL DC CHARACTERISTICS

FIGURE 2 – DC CURRENT GAIN

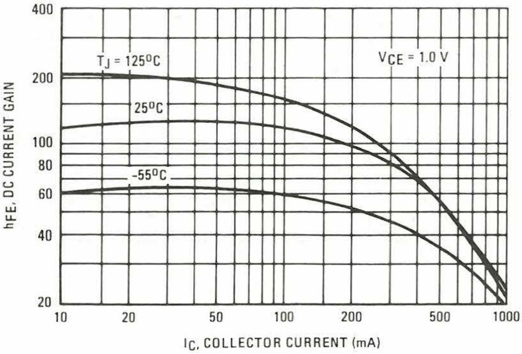
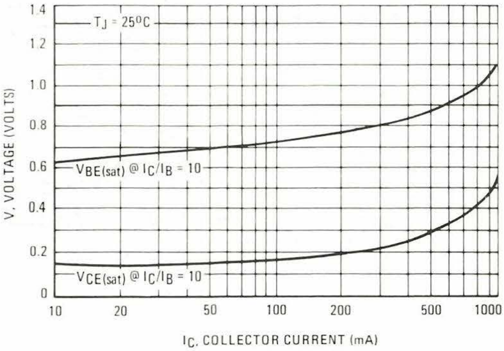


FIGURE 3 – "ON" VOLTAGES



4

FIGURE 4 – COLLECTOR SATURATION REGION

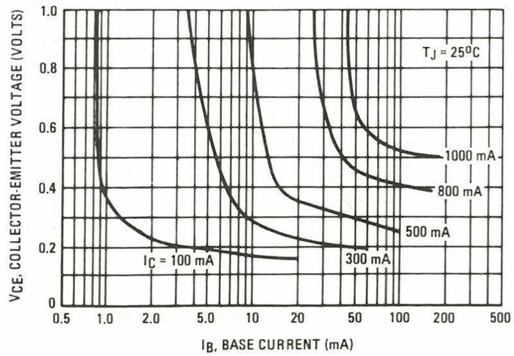
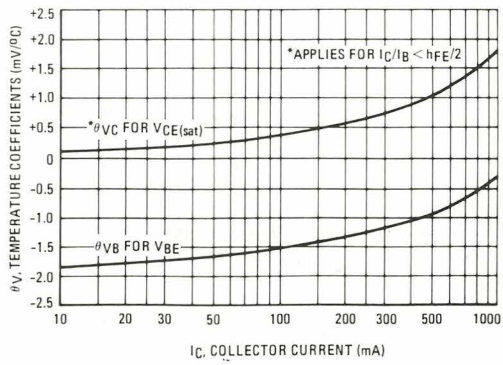


FIGURE 5 – TEMPERATURE COEFFICIENTS



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 6 – CURRENT-GAIN – BANDWIDTH PRODUCT

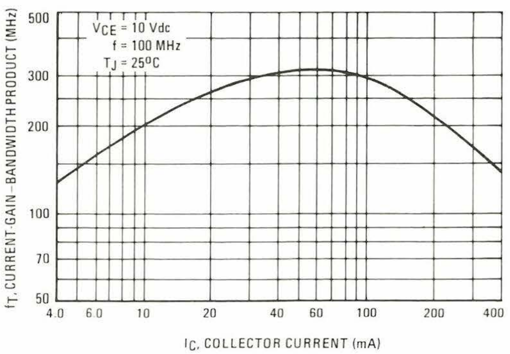


FIGURE 7 – CAPACITANCE

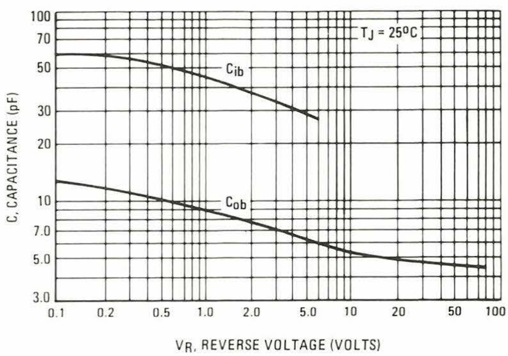


FIGURE 8 – TURN-ON TIME

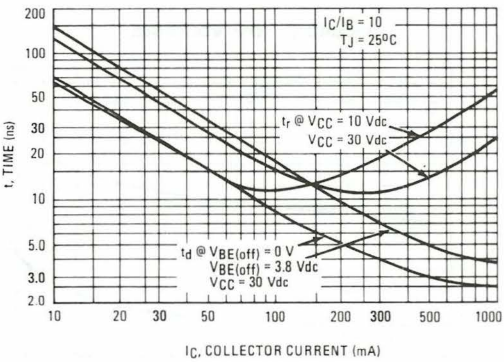


FIGURE 9 – TURN-OFF TIME

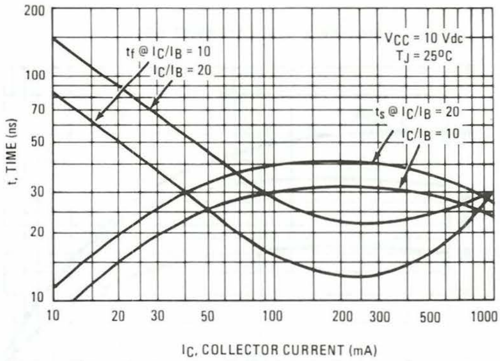


FIGURE 10 – SWITCHING TIME TEST CIRCUIT

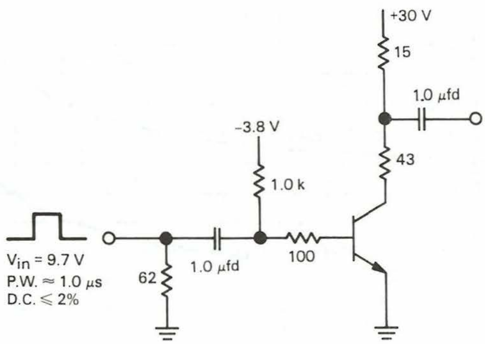
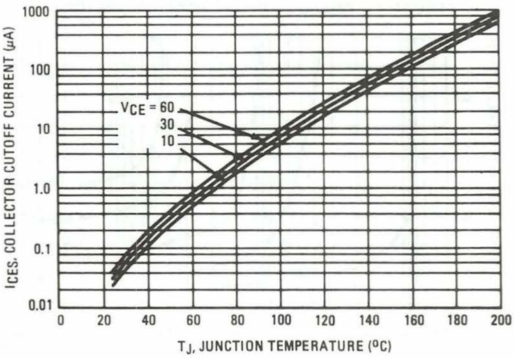


FIGURE 11 – COLLECTOR CUTOFF CURRENT



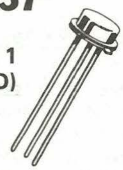
4

2N3734
2N3735

CASE 79, STYLE 1
TO-39 (TO-205AD)

2N3736
2N3737

CASE 26, STYLE 1
TO-46 (TO-206AD)



GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N3725 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N3734 2N3736	2N3735 2N3737	Unit
Collector-Emitter Voltage	V_{CEO}	30	50	Vdc
Collector-Base Voltage	V_{CBO}	50	75	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	1.5		Adc
		TO-39 2N3734 2N3735	TO-46 2N3736 2N3737	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71	0.5 2.86	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	4.0 22.8	2.0 11.4	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N3734 2N3736	2N3735 2N3737	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.044	0.088	°C/mW
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.175	0.35	°C/mW

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	 2N3734, 2N3736 2N3735, 2N3737	$V_{(BR)CEO}$	 30 50	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	 2N3734, 2N3736 2N3735, 2N3737	$V_{(BR)CBO}$	 50 75	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 25 Vdc, V_{EB} = 2 Vdc) (V_{CE} = 25 Vdc, V_{EB} = 2 Vdc, T_A = 100°C) (V_{CE} = 40 Vdc, V_{EB} = 2 Vdc) (V_{CE} = 40 Vdc, V_{EB} = 2 Vdc, T_A = 100°C)	 2N3734, 2N3736 2N3735, 2N3737 	I_{CEX}	 — — — —	 0.20 20 0.20 20	μAdc
Base Cutoff Current (V_{CE} = 25 Vdc, V_{EB} = 2 Vdc) (V_{CE} = 40 Vdc, V_{EB} = 2 Vdc)	 2N3734, 2N3736 2N3735, 2N3737	I_{BL}	 — —	 0.3 0.3	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 1 Vdc) (I_C = 150 mAdc, V_{CE} = 1 Vdc) (I_C = 500 mAdc, V_{CE} = 1 Vdc) (I_C = 1 Adc, V_{CE} = 1.5 Vdc) (I_C = 1.5 Adc, V_{CE} = 5 Vdc)	 2N3734, 2N3736 2N3735, 2N3737 2N3734, 2N3736 2N3735, 2N3737	h_{FE}	 35 40 35 30 20 30 20	 — — — 120 80 — —	—
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1 Adc, I_B = 100 mAdc)		$V_{CE(sat)}$	 — — — —	 0.2 0.3 0.5 0.9	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1 Adc, I_B = 100 mAdc)		$V_{BE(sat)}$	 — — — 0.9	 0.8 1.0 1.2 1.4	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	9.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	80	pF
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	h_{fe}	2.5	—	—
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 30 V, $V_{BE(off)}$ = 2.0 V, I_C = 1.0 Amp, I_{B1} = 100 mA)	t_{on}	—	40	ns
Turn-Off Time (V_{CC} = 30 V, $V_{BE(off)}$ = 2.0 V, I_C = 1.0 Amp, I_{B1} = 100 mA)	t_{off}	—	60	ns
Total Control Charge (I_C = 1 Amp, I_B = 100 mA, V_{CC} = 30 V)	Q_T	—	10	NC

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CBO}	300	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W

2N3742

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

NPN SILICON

4

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	300	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	300	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 200$ Vdc, $I_E = 0$) ($V_{CB} = 200$ Vdc, $I_E = 0$, $T_A = 100°C$)	I_{CBO}	 — —	 0.2 20	μAdc
Emitter Cutoff Current ($V_{EB} = 6.0$ Vdc, $I_C = 0$)	I_{EBO}	—	0.2	μAdc
ON CHARACTERISTICS(2)				
DC Current Gain ($I_C = 3.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 20$ Vdc)	h_{FE}	 10 15 20 20	 — — 200 —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc)	$V_{CE(sat)}$	 — —	 0.75 1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc)	$V_{BE(sat)}$	 — —	 1.0 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(3) ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 20 MHz)	f_T	30	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	6.0	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)	C_{ibo}	—	80	pF
Input Impedance ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{ie}	—	2.0	k ohms
Voltage Feedback Ratio ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{re}	—	2.0	$X10^{-4}$
Small-Signal Current Gain ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 10 kHz)	h_{fe}	20	200	—

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	—	50	mhos
Real Part of Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 5.0 MHz)	$Re(h_{ie})$	—	200	Ohms

(1) Pulse Test: Pulse Width ≤ 30 μs, Duty Cycle ≤ 1.0%.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(3) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 — DC CURRENT GAIN

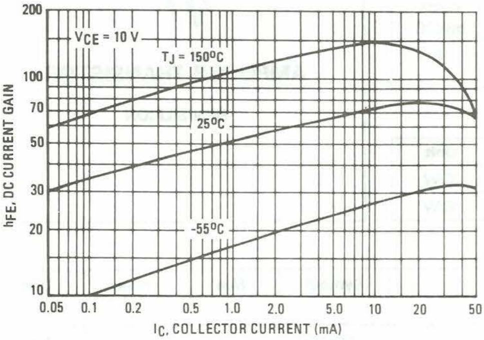


FIGURE 2 — DC SAFE OPERATING AREA

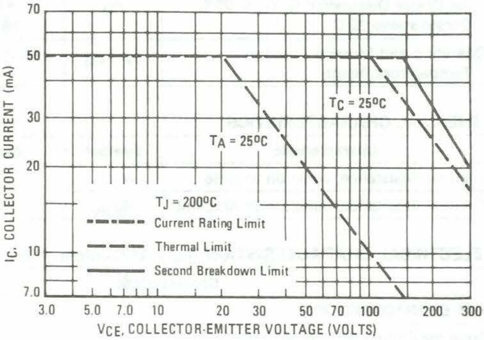


FIGURE 3 — "ON" VOLTAGES

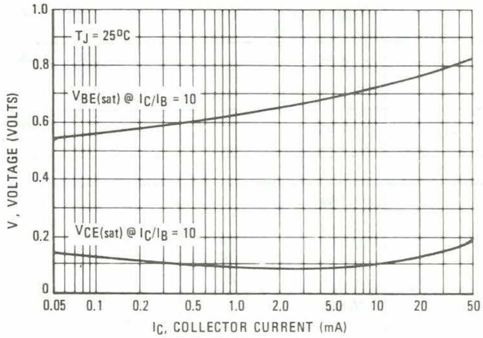


FIGURE 4 — TEMPERATURE COEFFICIENTS

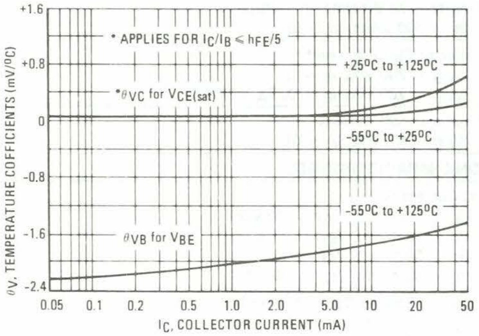


FIGURE 5 — CURRENT-GAIN-BANDWIDTH PRODUCT

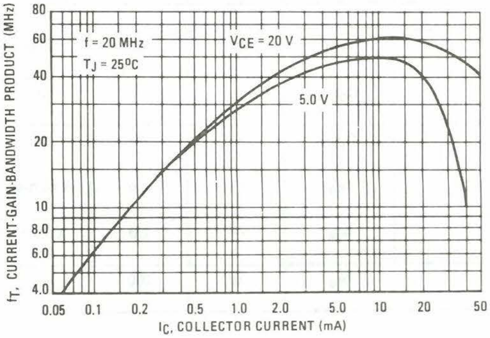
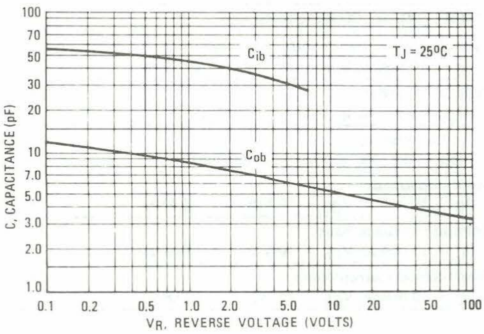
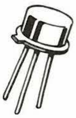


FIGURE 6 — CAPACITANCE



2N3743

JAN, JTX AVAILABLE
CASE 79, STYLE 1
TO-39 (TO-205AD)



AMPLIFIER TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CBO}	300	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.7	Watts mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	300	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	300	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 200$ Vdc, $I_E = 0$) ($V_{CB} = 200$ Vdc, $I_E = 0$, $T_A = 100°C$)	I_{CBO}	 — —	 0.3 30	μAdc
Emitter Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain(2) ($I_C = 100$ μAdc, $V_{CE} = 10$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 20$ Vdc)	h_{FE}	 20 25 25 25 25	 — — — 250 —	—
Collector-Emitter Saturation Voltage(2) ($I_C = 10$ mAdc, $I_B = 1$ mAdc) ($I_C = 30$ mAdc, $I_B = 3$ mAdc)	$V_{CE(sat)}$	 — —	 5.0 8.0	Vdc
Base-Emitter Saturation Voltage(2) ($I_C = 10$ mAdc, $I_B = 1$ mAdc) ($I_C = 30$ mAdc, $I_B = 3$ mAdc)	$V_{BE(sat)}$	 — —	 1.0 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	15	pF
Input Capacitance ($V_{EB} = 1.0$ Vdc, $I_C = 0$, f = 100 kHz)	C_{ibo}	—	400	pF
Input Impedance ($V_{CE} = 10$ V, $I_C = 10$ mA, f = 1 kHz)	h_{ie}	—	1.0	kohms
Voltage Feedback Ratio ($V_{CE} = 10$ V, $I_C = 10$ mA, f = 1 kHz)	h_{re}	—	4.0	$\times 10^{-4}$
Small-Signal Current Gain ($V_{CE} = 10$ V, $I_C = 10$ mA, f = 1 kHz)	h_{fe}	30	300	—

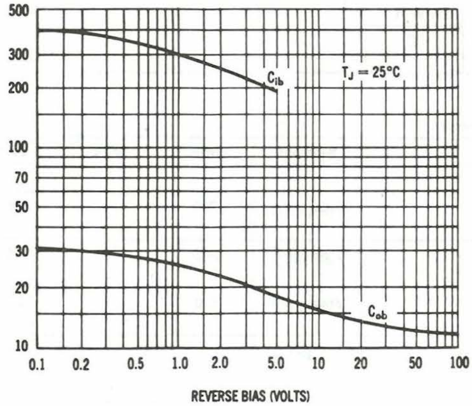
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Current Gain — High Frequency (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	$\|h_{fe}\|$	1.5	—	—
Output Admittance (V_{CE} = 10 V, I_C = 10 mA, f = 1 kHz)	h_{oe}	—	200	μmhos
Real Part of Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 5 MHz)	$Re(h_{ie})$	—	40	ohms

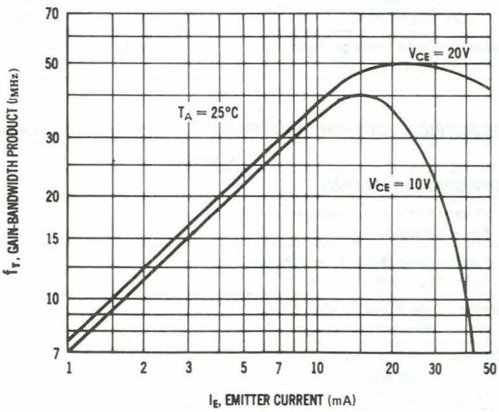
(1) PW ≤ 30 μs, Duty Cycle ≤ 1.0%.
(2) PW ≤ 300 μs, Duty Cycle ≤ 2.0%.

4

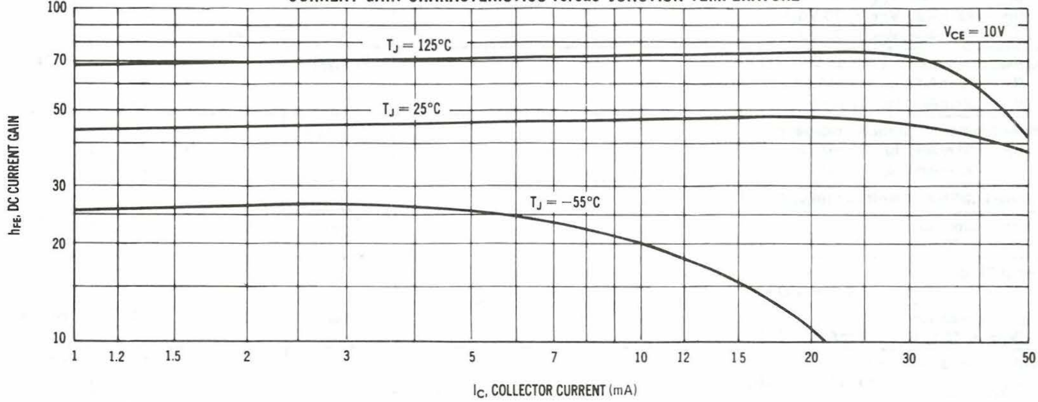
JUNCTION CAPACITANCE



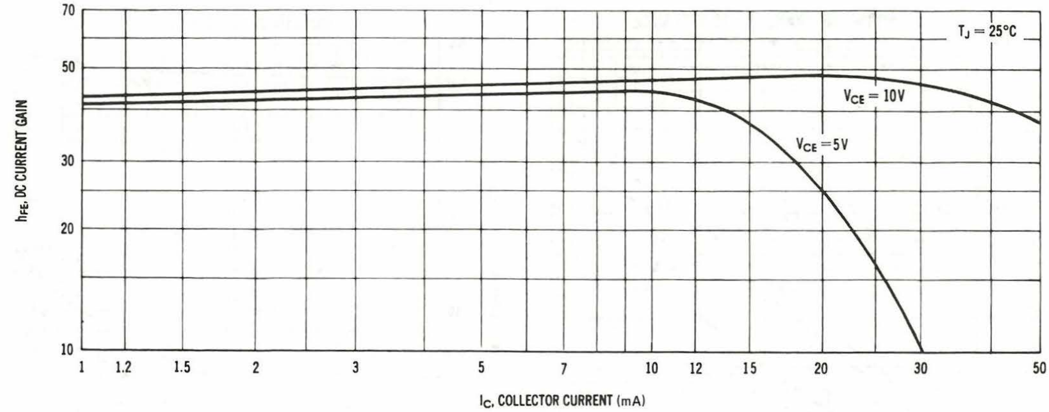
GAIN-BANDWIDTH PRODUCT



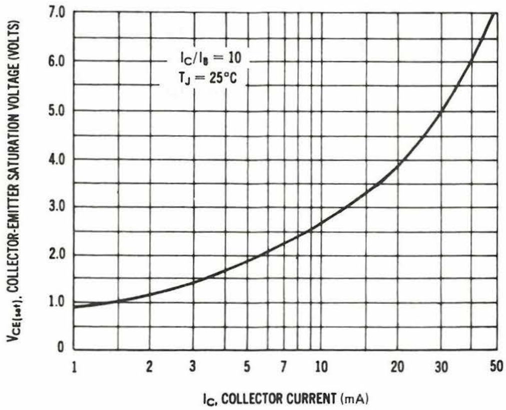
CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE



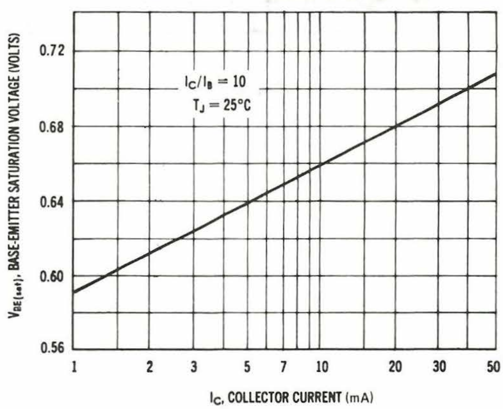
CURRENT GAIN CHARACTERISTICS versus COLLECTOR-EMITTER VOLTAGE



COLLECTOR-EMITTER SATURATION VOLTAGE



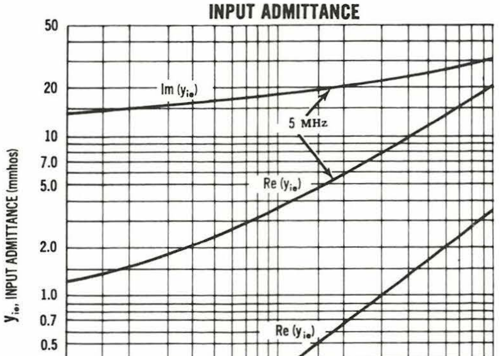
BASE-EMITTER SATURATION VOLTAGE



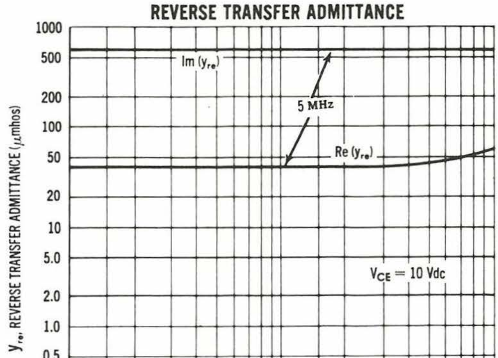
SMALL SIGNAL y PARAMETERS

$T_A = 25°C$

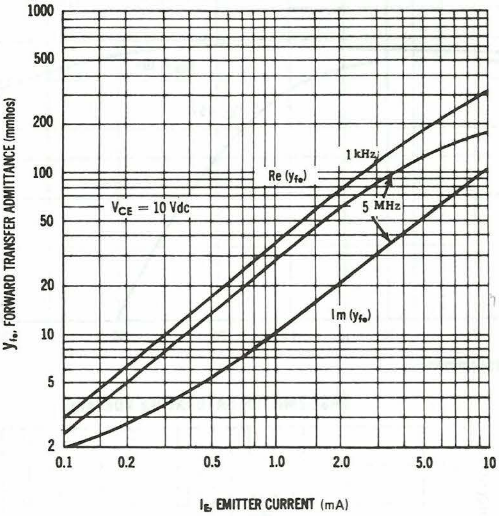
INPUT ADMITTANCE



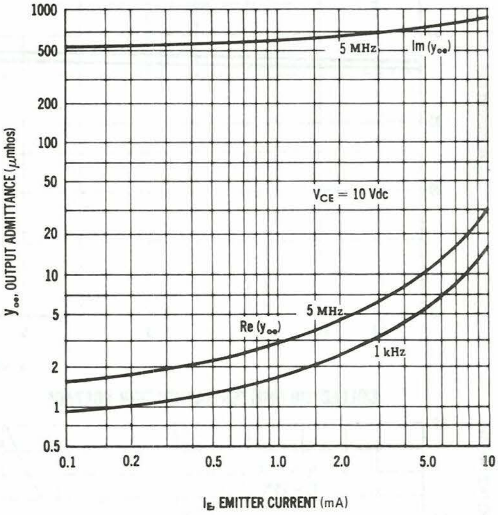
REVERSE TRANSFER ADMITTANCE



FORWARD TRANSFER ADMITTANCE



OUTPUT ADMITTANCE



MAXIMUM RATINGS

Rating	Symbol	2N3762 2N3764	2N3763 2N3765	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	40	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	1.5		Adc
		TO-39 2N3762 2N3763	TO-46 2N3764 2N3765	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71	0.5 2.86	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	4.0 22.8	2.0 11.4	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C
Lead Temperature 1/16″ from Case for 10 Seconds	T_L	+235		°C

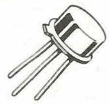
THERMAL CHARACTERISTICS

Characteristic	Symbol	2N3762 2N3763	2N3764 2N3765	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	44	88	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	350	°C/W

2N3762
2N3763

JAN, JTX, JTXV AVAILABLE

CASE 79, STYLE 1
TO-39



2N3764
2N3765

CASE 26, STYLE 1
TO-46

SWITCHING TRANSISTOR

PNP SILICON

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	 2N3762, 2N3764 2N3763, 2N3765	$V_{(BR)CEO}$	 40 60	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	 2N3762, 2N3764 2N3763, 2N3765	$V_{(BR)CBO}$	 40 60	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{EB} = 2.0 Vdc) (V_{CE} = 20 Vdc, V_{EB} = 2.0 Vdc, T_A = 100°C) (V_{CE} = 30 Vdc, V_{EB} = 2.0 Vdc) (V_{CE} = 30 Vdc, V_{EB} = 2.0 Vdc, T_A = 100°C)	 2N3762, 2N3764 2N3763, 2N3765 	I_{CEX}	 — — — —	 0.10 10 0.10 10	μAdc
Base Cutoff Current (V_{CE} = 20 Vdc, V_{EB} = 2.0 Vdc) (V_{CE} = 30 Vdc, V_{EB} = 2.0 Vdc)	 2N3762, 2N3764 2N3763, 2N3765	I_{BL}	 — —	 0.2 0.2	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 150 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 1.5 Vdc) (I_C = 1.5 Adc, V_{CE} = 5.0 Vdc)	 2N3762, 2N3764 2N3763, 2N3765 2N3762, 2N3764 2N3763, 2N3765	h_{FE}	 35 40 35 30 20 30 20	 — — — 120 80 — —	—
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1.0 Adc, I_B = 100 mAdc)		$V_{CE(sat)}$	 — — — —	 0.1 0.22 0.5 0.9	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1.0 Adc, I_B = 100 mAdc)		$V_{BE(sat)}$	 — — — 0.9	 0.8 1.0 1.2 1.4	Vdc

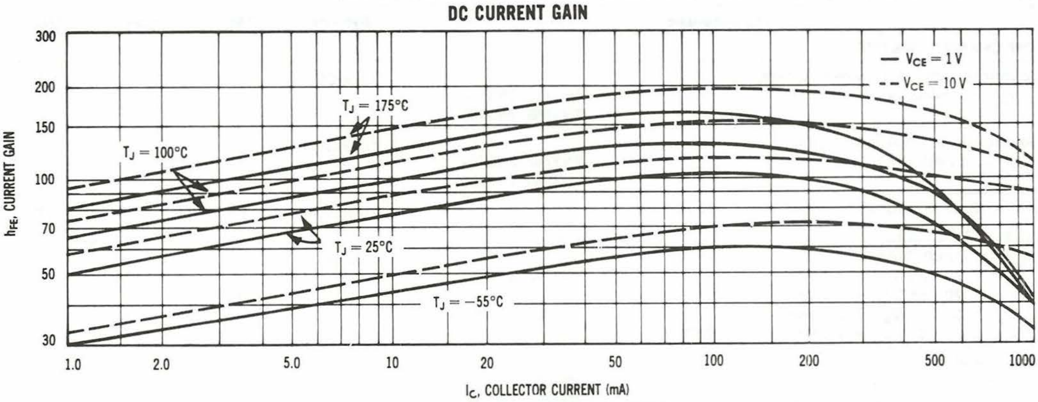
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	80	pF
Current Gain — High Frequency (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N3762, 2N3764	$\|h_{fe}\|$	1.8	—	—
	2N3763, 2N3765		1.5	—	
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 30 V, $V_{BE(off)}$ = 2.0 V, I_C = 1.0 Amp, I_{B1} = 100 mA)	t_d	—	8.0	ns
Rise Time		t_r	—	3.5	ns
Storage Time	(V_{CC} = 30 V, I_C = 1.0 Amp, I_{B1} = $-I_{B2}$ = 100 mA)	t_s	—	80	ns
Fall Time		t_f	—	35	ns
Total Control Charge (I_C = 1.0 Amp, I_B = 100 mA, V_{CC} = 30 V)		Q_T	—	30	pC

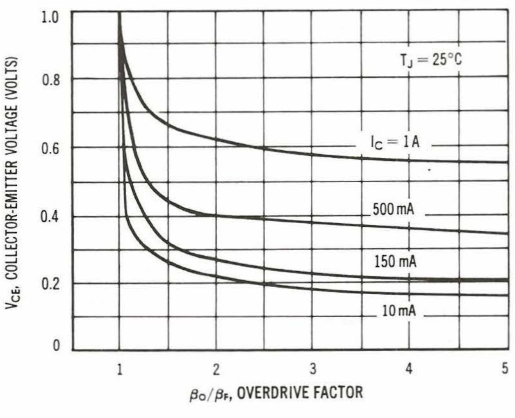
(1) Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2.0%.

"ON" CONDITION CHARACTERISTICS

DC CURRENT GAIN



COLLECTOR SATURATION REGION

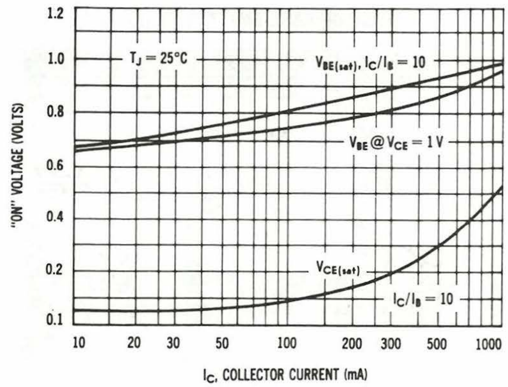


This graph shows the effect of base current on collector current. β_O (current gain at the edge of saturation) is the current gain of the transistor at 1 volt, and β_F (forced gain) is the ratio of I_C/I_{BF} in a circuit. EXAMPLE: For type 2N3734, estimate a base current (I_{BF}) to ensure saturation at a temperature of 25°C and a collector of 500 mA.

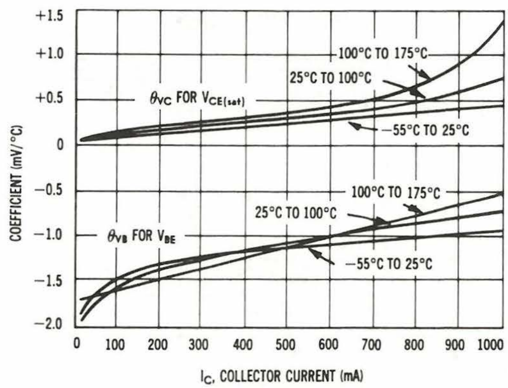
Observe that at I_C = 500 mA an overdrive factor of at least 2.0 is required to drive the transistor well into the saturation region. From Figure 1, it is seen that h_{FE} @ 1 volt is typically 54 (guaranteed limits from the Table of Characteristics can be used for "worst-case" design).

$$\frac{\beta_O}{\beta_F} = \frac{h_{FE} @ 1\ \text{Volt}}{I_C/I_{BF}} \qquad 2 = \frac{54}{500\ \text{mA}/I_{BF}} \qquad I_{BF} \approx 18.5\ \text{mA typ}$$

"ON" VOLTAGES



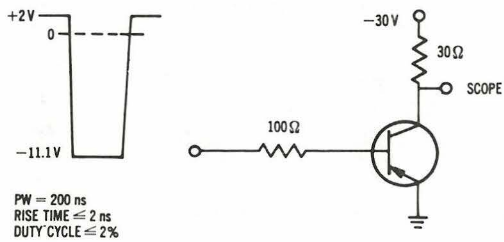
TEMPERATURE COEFFICIENTS



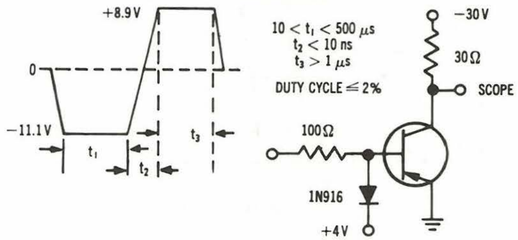
4

SWITCHING TIME EQUIVALENT TEST CIRCUITS

TURN-ON TIME

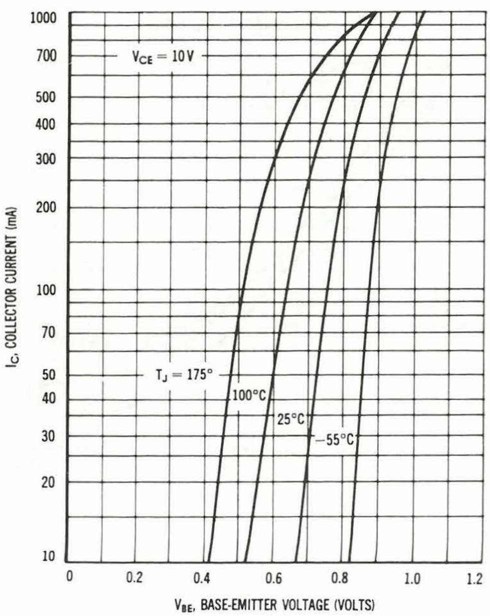


TURN-OFF TIME



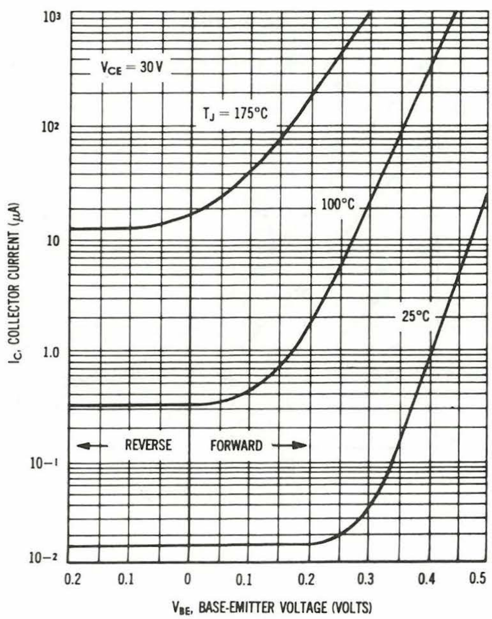
LARGE SIGNAL CHARACTERISTICS

TRANSCONDUCTANCE



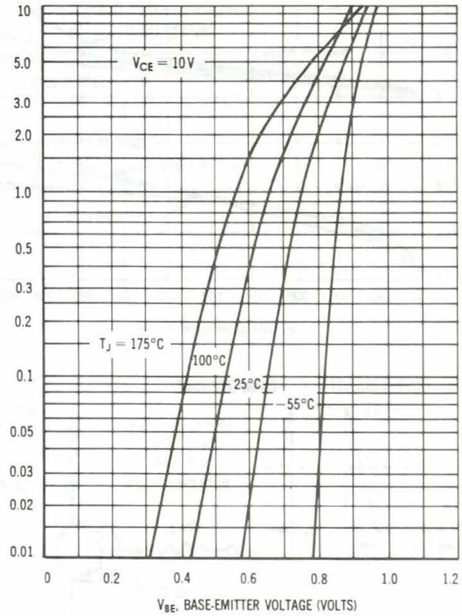
"OFF" CONDITION CHARACTERISTICS

TRANSCONDUCTANCE

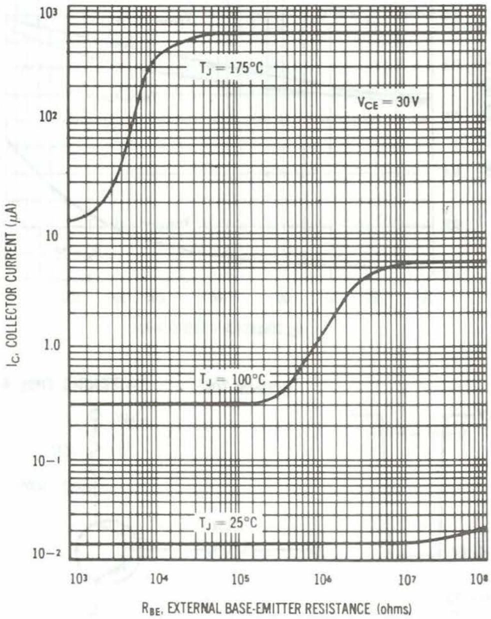


4

INPUT ADMITTANCE

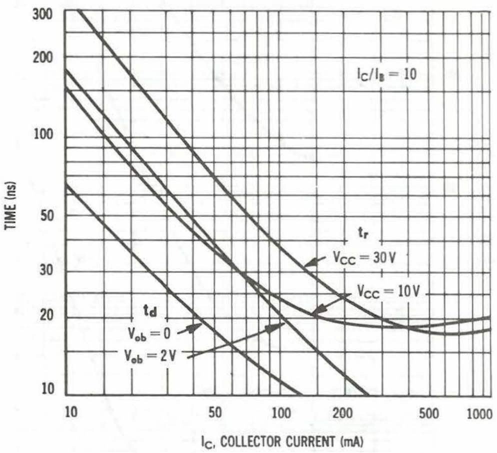


EFFECT OF BASE-EMITTER RESISTANCE

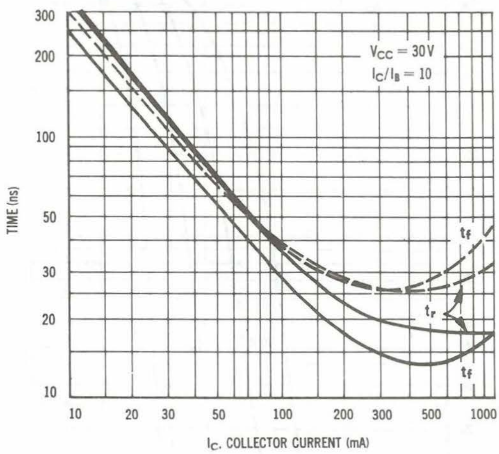


— $T_J = 25°C$ SWITCHING CHARACTERISTICS - - $T_J = 150°C$

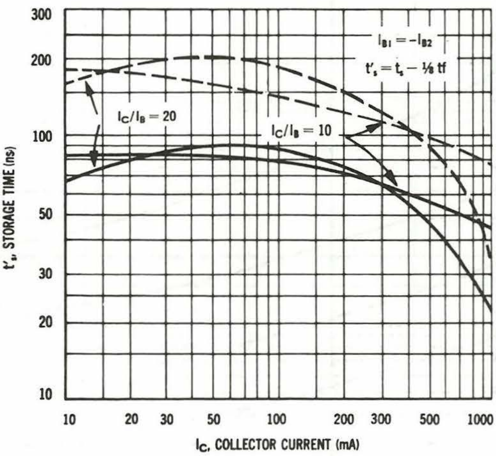
TURN-ON TIME



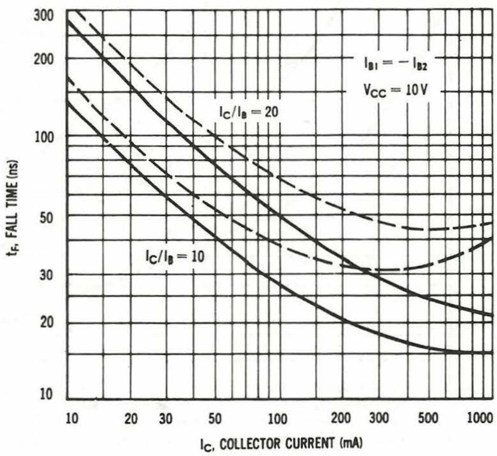
RISE AND FALL TIME



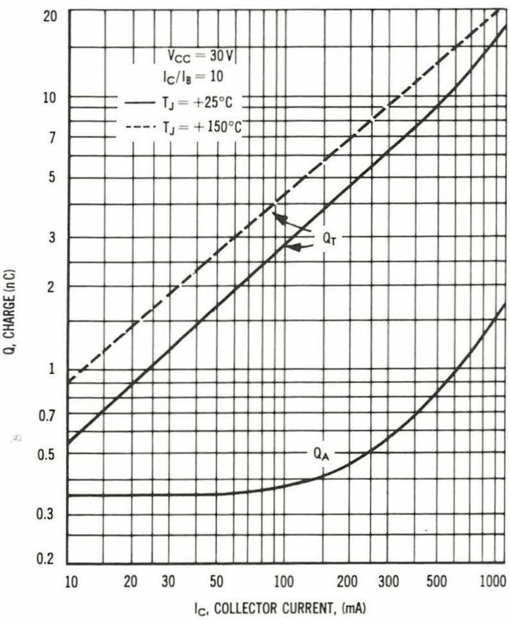
STORAGE TIME



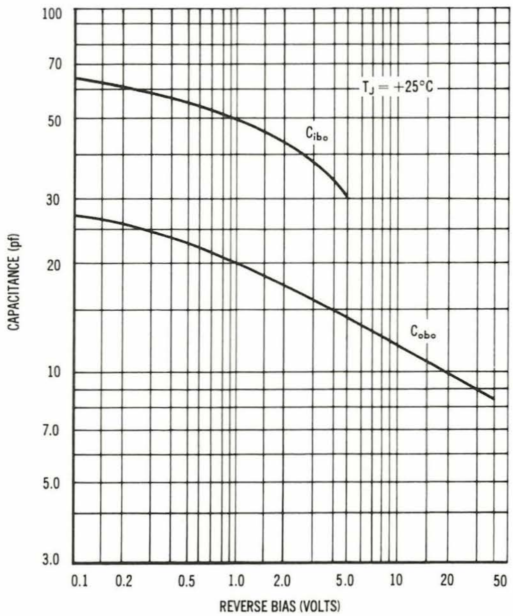
FALL TIME



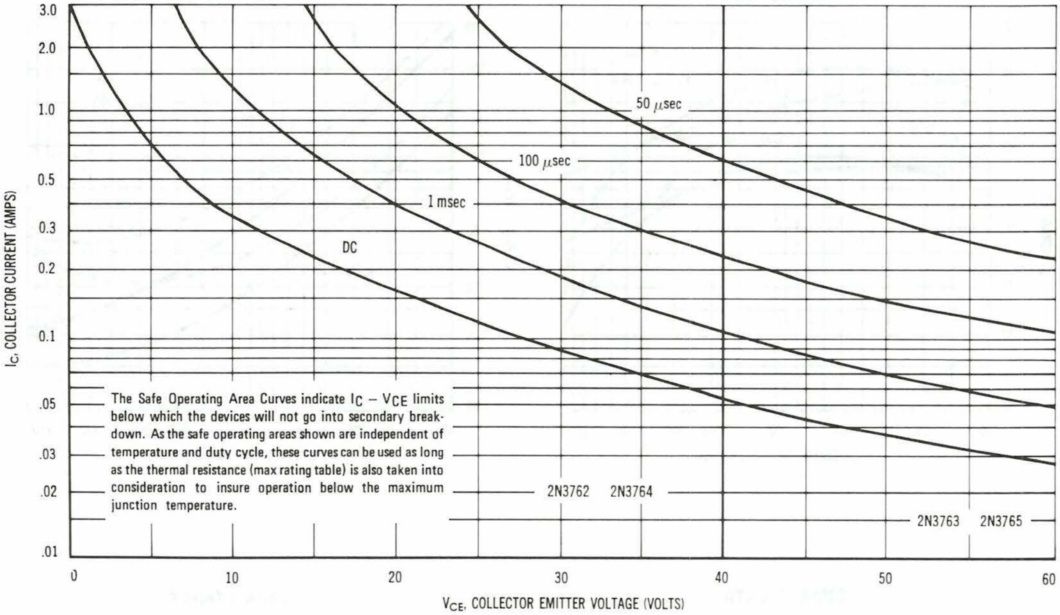
CHARGE DATA



CAPACITANCE



ACTIVE REGION SAFE OPERATING AREAS



2N3798
2N3799

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

AMPLIFIER TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N3798 2N3799	2N3798A 2N3799A	Unit
Collector-Emitter Voltage	V_{CEO}	60	90	Vdc
Collector-Base Voltage	V_{CBO}	60	90	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.36 2.06		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.2 6.86		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.15	°C/mW
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.49	°C/mW

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)	2N3798, 2N3799	$V_{(BR)CEO}$	60	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	2N3798, 2N3799	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$) ($V_{CB} = 50$ Vdc, $I_E = 0$, $T_A = 150°C$)		I_{CBO}	 — —	 — —	 0.01 10	μAdc
Emitter Cutoff Current ($V_{BE} = 4.0$ Vdc, $I_C = 0$)		I_{EBO}	—	—	20	nAdc
ON CHARACTERISTICS						
DC Current Gain(1) ($I_C = 1.0\ \mu$Adc, $V_{CE} = 5.0$ Vdc)	 2N3799	h_{FE}	 75	 —	 —	—
($I_C = 10\ \mu$Adc, $V_{CE} = 5.0$ Vdc)	2N3798 2N3799		100 225	— —	— —	
($I_C = 100\ \mu$Adc, $V_{CE} = 5.0$ Vdc)	2N3798 2N3799		150 300	— —	— —	
($I_C = 100\ \mu$Adc, $V_{CE} = 5.0$ Vdc, $T_A = -55°C$)	2N3798 2N3799		75 150	— —	— —	
($I_C = 500\ \mu$Adc, $V_{CE} = 5.0$ Vdc)	2N3798 2N3799		150 300	— —	450 900	
($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)	2N3798 2N3799		150 300	— —	— —	
($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	2N3798 2N3799		125 250	— —	— —	
Collector-Emitter Saturation Voltage(1) ($I_C = 100\ \mu$Adc, $I_B = 10\ \mu$Adc) ($I_C = 1.0$ mAdc, $I_B = 100\ \mu$Adc)		$V_{CE(sat)}$	 — —	 — —	 0.2 0.25	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 100\ \mu$Adc, $I_B = 10\ \mu$Adc) ($I_C = 1.0$ mAdc, $I_B = 100\ \mu$Adc)		$V_{BE(sat)}$	 — —	 — —	 0.7 0.8	Vdc
Base-Emitter On Voltage ($I_C = 100\ \mu$Adc, $V_{CE} = 5.0$ Vdc)		$V_{BE(on)}$	—	—	0.7	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(2)		f_T				MHz
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 30 MHz)			30	—	—	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)			100	—	500	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	—	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	—	8.0	pF
Input Impedance		h_{ie}				k ohms
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3798		3.0	—	15	
	2N3799		10	—	40	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{re}	—	—	25	X 10^{-4}
Small-Signal Current Gain		h_{fe}				—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3798		150	—	600	
	2N3799		300	—	900	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	5.0	—	60	μmhos
Noise Figure		NF				dB
(I_C = 100 μAdc, V_{CE} = 10 Vdc, R_G = 3.0 k ohms), f = 100 Hz, B.W. = 20 Hz	2N3798		—	4.0	7.0	
	2N3799		—	2.5	4.0	
Spot Noise f = 1.0 kHz, B.W. = 200 Hz	2N3798		—	1.5	3.0	
	2N3799		—	0.8	1.5	
f = 10 kHz, B.W. = 2.0 kHz	2N3798		—	1.0	2.5	
	2N3799		—	0.8	1.5	
Broadband Noise-Bandwidth 10 Hz to 15.7 kHz	2N3798		—	2.5	3.5	
	2N3799		—	1.5	2.5	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

SPOT NOISE FIGURE
(V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 1 — SOURCE RESISTANCE EFFECTS, f = 1.0 kHz

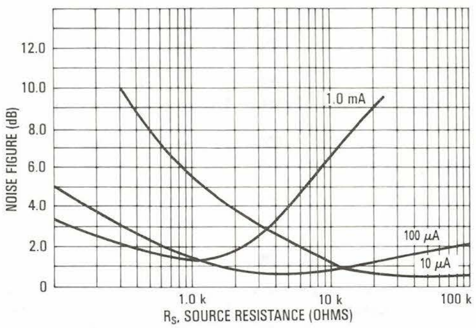


FIGURE 2 — SOURCE RESISTANCE EFFECTS, f = 10 Hz

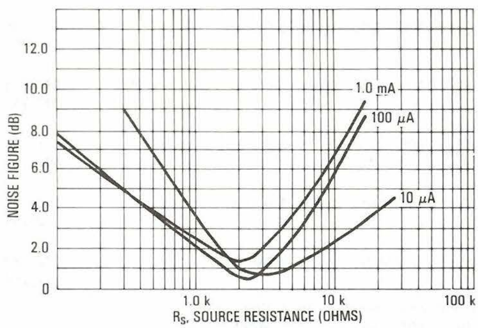


FIGURE 3 — FREQUENCY EFFECTS

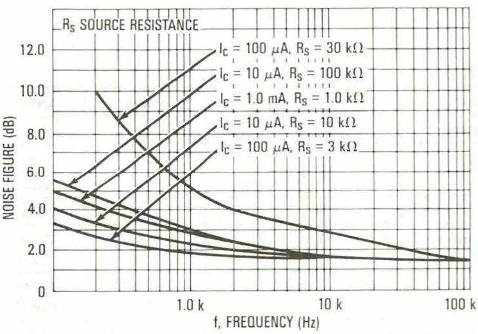


FIGURE 4a — TYPICAL CURRENT GAIN CHARACTERISTICS—2N3798

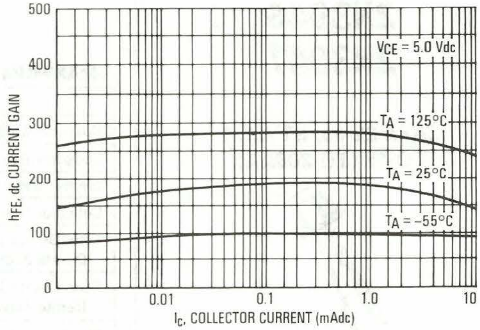
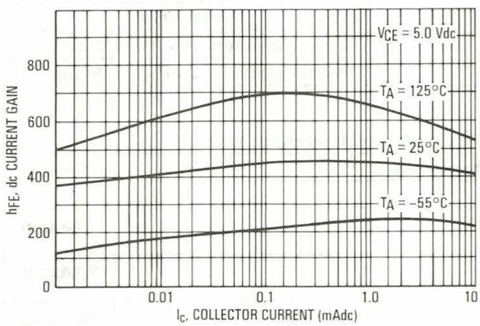


FIGURE 4b — TYPICAL CURRENT GAIN CHARACTERISTICS — 2N3799



4

4

2N3946
2N3947

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.2 6.9	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.15	°C/mW
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.49	°C/mW

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc)		$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CE} = 40 Vdc, V_{OB} = 3.0 Vdc) (V_{CE} = 40 Vdc, V_{OB} = 3.0 Vdc, T_A = 150°C)		I_{CEX}	 — —	 0.010 15	μAdc
Base Cutoff Current (V_{CE} = 40 Vdc, V_{OB} = 3.0 Vdc)		I_{BL}	—	.025	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	 2N3946 2N3947	h_{FE}	 30 60	 — —	—
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	2N3946 2N3947		45 90	— —	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N3946 2N3947		50 100	150 300	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	2N3946 2N3947		20 40	— —	
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	 — —	 0.2 0.3	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{BE(sat)}$	 0.6 —	 0.9 1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	 2N3946 2N3947	f_T	 250 300	 — —	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	4.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Input Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	8.0	pF
Input Impedance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)	2N3946 2N3947	h_{ie}	0.5 2.0	6.0 12	kohms
Voltage Feedback Ratio (I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)	2N3946 2N3947	h_{re}	— —	10 20	X 10^{-4}
Small Signal Current Gain (I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)	2N3946 2N3947	h_{fe}	50 100	250 700	—
Output Admittance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz)	2N3946 2N3947	h_{oe}	1.0 5.0	30 50	μmhos
Collector Base Time Constant (I_C = 10 mA, V_{CE} = 20 V, f = 31.8 MHz)		$r_{b'}C_c$	—	200	ps
Noise Figure (I_C = 100 μA, V_{CE} = 5.0 V, R_g = 1.0 kΩ, f = 10 Hz to 15.7 kHz)		NF	—	5.0	dB

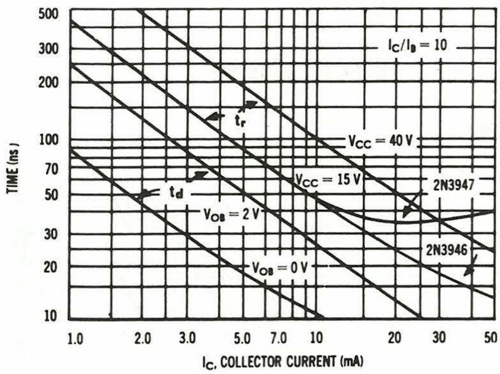
SWITCHING CHARACTERISTICS

			Symbol	Min	Max	Unit
Delay Time	V_{CC} = 3.0 Vdc, V_{OB} = 0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mA		t_d	—	35	ns
Rise Time			t_r	—	35	ns
Storage Time	V_{CC} = 3.0 V, I_C = 10 mA,	2N3946 2N3947	t_s	— —	300 375	ns
Fall Time	I_{B1} = I_{B2} = 1.0 mAdc		t_f	—	75	ns

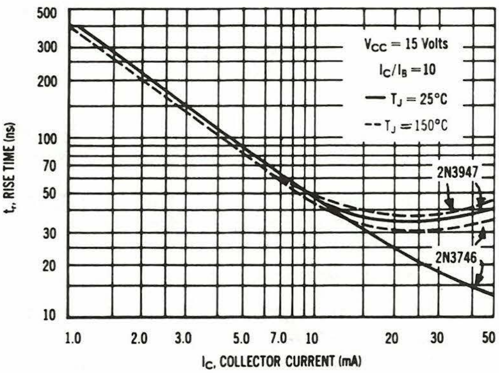
(1) Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2%.

TYPICAL SWITCHING CHARACTERISTICS
(T_A = 25°C unless otherwise noted)

DELAY AND RISE TIME



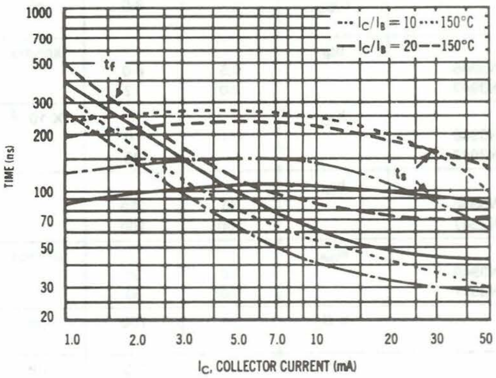
RISE TIME



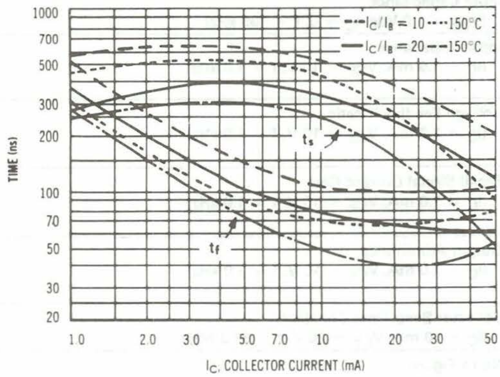
4

STORAGE AND FALL TIMES

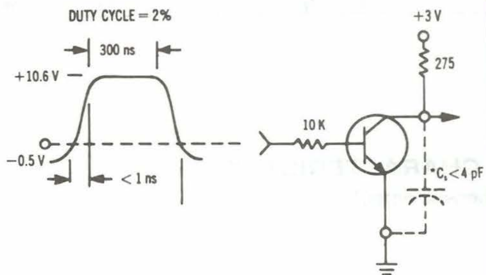
2N3946



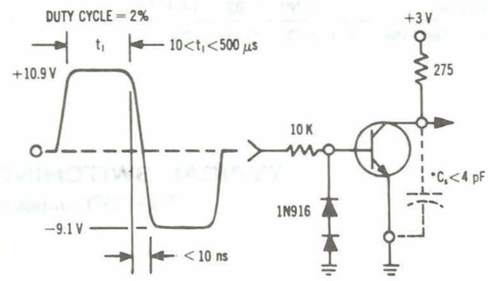
2N3947



TURN-ON TIME EQUIVALENT TEST CIRCUIT



TURN-OFF TIME EQUIVALENT TEST CIRCUIT

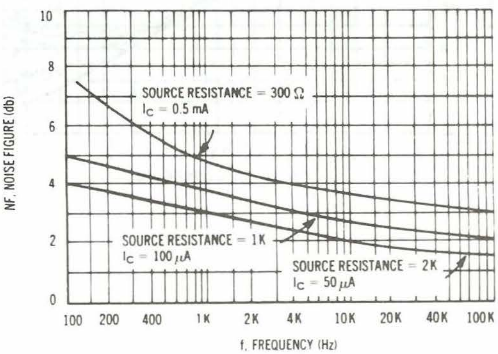


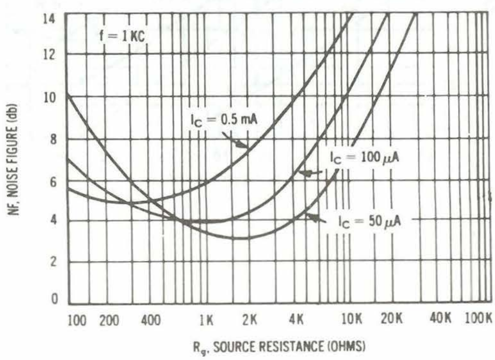
*TOTAL SHUNT CAPACITANCE OF TEST JIG AND CONNECTORS

AUDIO SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE VARIATIONS

$V_{CE} = 5$ V, $T_A = 25°C$

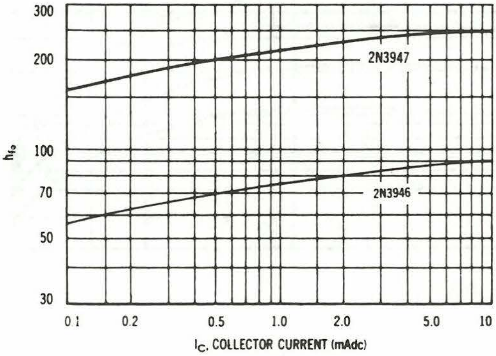




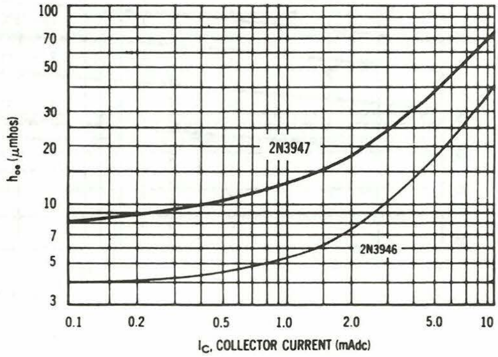
h PARAMETERS

$V_{CE} = 10$ V, $T_A = 25°C$, f = 1 Kc

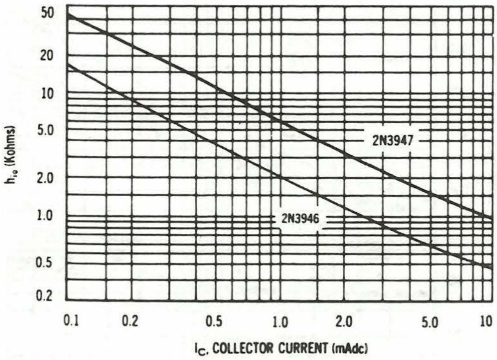
CURRENT GAIN



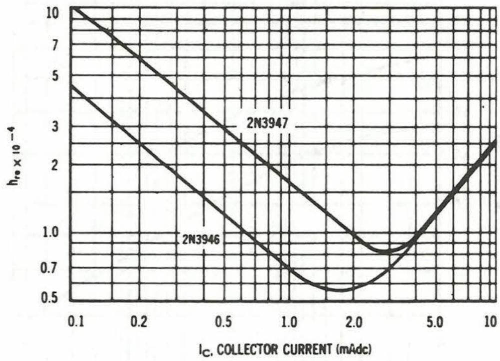
OUTPUT ADMITTANCE



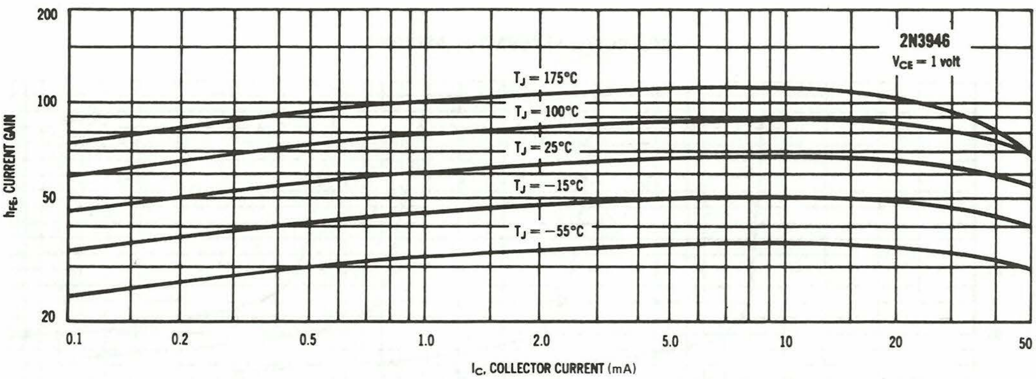
INPUT IMPEDANCE



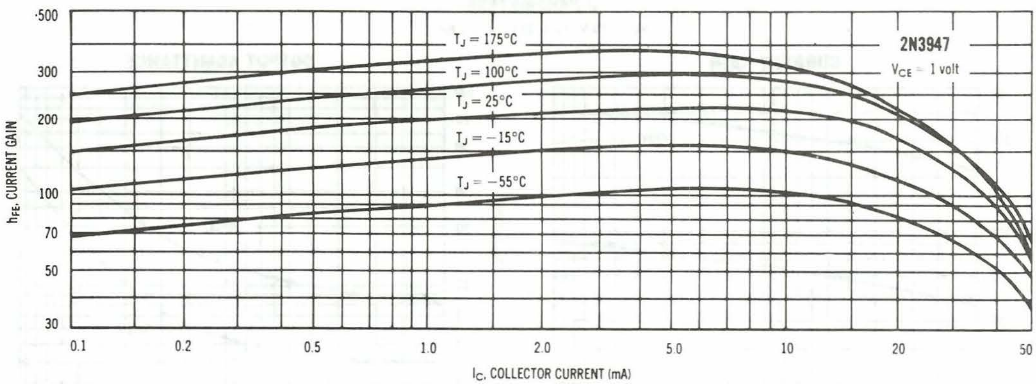
VOLTAGE FEEDBACK RATIO



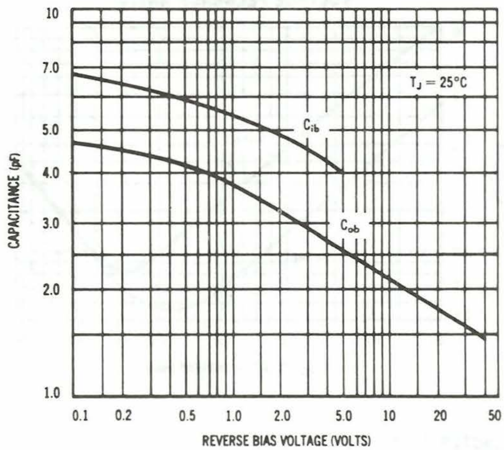
CURRENT GAIN CHARACTERISTICS



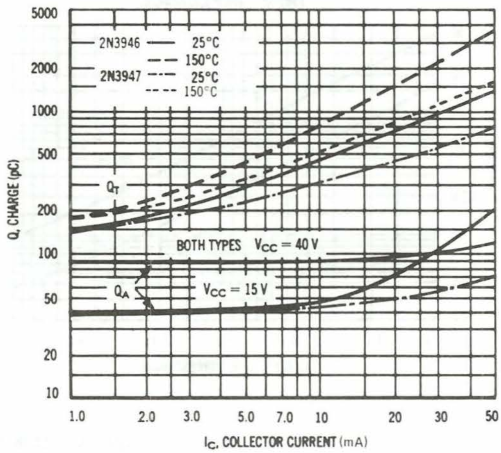
4



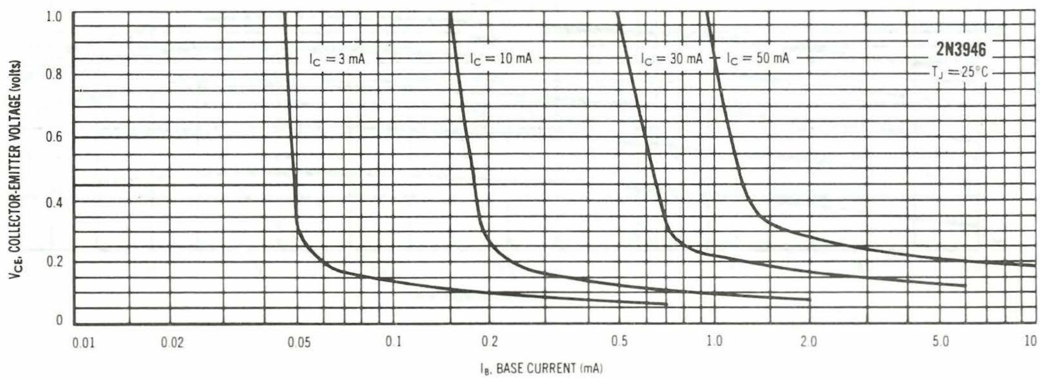
CAPACITANCE

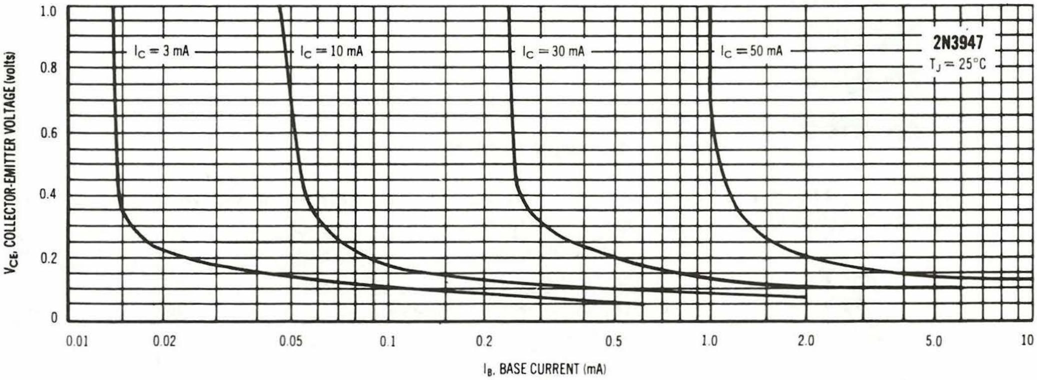


CHARGE DATA



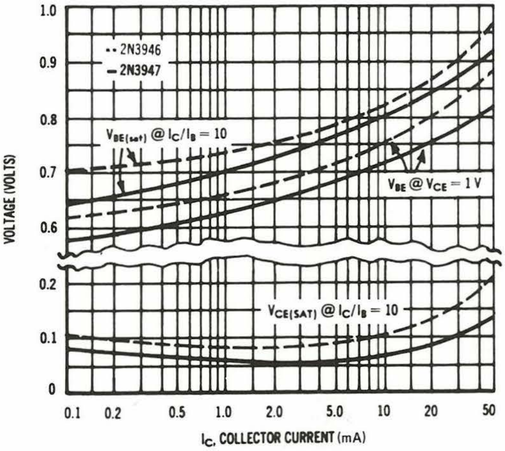
COLLECTOR SATURATION REGION



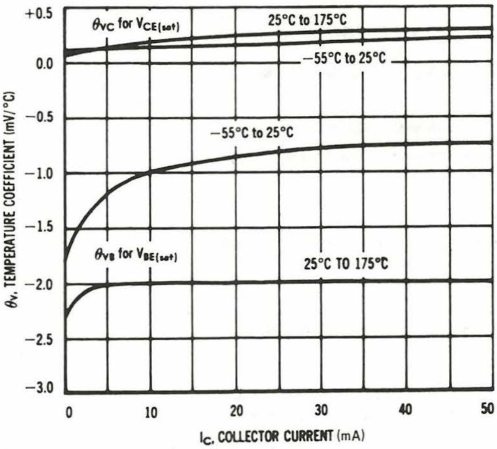


4

"ON" VOLTAGES



TEMPERATURE COEFFICIENTS



2N3962
2N3963
2N3964
2N3965

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

AMPLIFIER TRANSISTOR

PNP SILICON

4

Refer to 2N3798 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N3962 2N3965	2N3964	2N3963	Unit
Collector-Emitter Voltage	V_{CEO}	60	45	80	V
Collector-Base Voltage	V_{CBO}	60	45	80	V
Emitter-Base Voltage	V_{EBO}	6.0			V
Collector Current — Continuous	I_C	200			mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.36 2.06			Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.2 6.85			Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200			°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 ma)	2N3962, 2N3965 2N3963 2N3964	$V_{(BR)CEO}$	60 80 45	— — —	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μA)	2N3962, 2N3965 2N3963 2N3964	$V_{(BR)CES}$	60 80 45	— — —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μA)	2N3962, 2N3965 2N3963 2N3964	$V_{(BR)CBO}$	60 80 45	— — —	Vdc
Emitter-Base Breakdown Voltage (I_C = 10 μA)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CE} = 50 V; 2N3964 = 40 V) (V_{CE} = 70 V)	2N3965, 2N3962 2N3963	I_{CBO}	— —	10 10	nAdc
Collector Cutoff Current (V_{CE} = 50 V) (V_{CE} = 70 V) (V_{CE} = 40 V) (V_{CE} = 50 V)	2N3962 2N3963 2N3964 2N3965	I_{CES}	— — — —	10 10 10 10	nAdc
Emitter Cutoff Current (V_{EB} = 4.0 V)		I_{EBO}	—	10	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 10 μA, V_{CE} = 5.0 V)	2N3962, 2N3963 2N3964, 2N3965	h_{FE}	100 250	300 500	—
(I_C = 100 μA, V_{CE} = 5.0 V)	2N3962, 2N3963 2N3964, 2N3965		100 250	— —	
(I_C = 1.0 mA, V_{CE} = 5.0)	2N3962, 2N3963 2N3964, 2N3965		100 250	450 600	
(I_C = 10 μA, V_{CE} = 5.0, T_A = −55°C)	2N3962, 2N3963 2N3964, 2N3965		40 100	— —	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
(I_C = 1.0 mA, V_{CE} = 5.0 V, T_A = 100°C)	2N3962, 2N3963 2N3964, 2N3965		— —	600 800	
(I_C = 1.0 μA, V_{CE} = 5.0 V)	2N3962, 2N3963 2N3964, 2N3965		60 180	— —	
(I_C = 10 mA, V_{CE} = 5.0 V)	2N3962, 2N3963 2N3964, 2N3965		100 200	— —	
(I_C = 50 mA, V_{CE} = 5.0 V)	2N3962, 2N3963 2N3964, 2N3965		90 180	— —	
(I_C = 50 mA, V_{CE} = 5.0 V, T_A = −55°C)	2N3962, 2N3963 2N3964, 2N3965		45 90	— —	
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.5 mA) (I_C = 50 mA, I_B = 5.0 mA)(1)		$V_{CE(sat)}$	 — —	 0.25 0.4	 V V
Base-Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.5 mA) (I_C = 50 mA, I_B = 5.0 mA)(1)		$V_{BE(sat)}$	 — —	 0.9 0.95	 V V

SMALL-SIGNAL CHARACTERISTICS

Characteristic		Symbol	Min	Max	Unit
Output Capacitance (V_{CB} = 5.0 V, f = 1.0 MHz)		C_{obo}	—	6.0	pF
Input Capacitance (V_{EB} = 0.5 V, f = 1.0 MHz)		C_{ibo}	—	15	pF
Input Impedance (I_C = 1.0 mA, V_{CE} = 5.0 V, f = 1.0 kHz)	 2N3962, 2N3963 2N3964, 2N3965	h_{ie}	 2.5 6.0	 17 20	kΩ
Voltage Feedback Ratio (I_C = 1.0 mA, V_{CE} = 5.0, f = 1.0 kHz)		h_{re}	—	10	10^{-4}
Small-Signal Current Gain (I_C = 1.0 mA, V_{CE} = 5.0 V, f = 1.0 kHz)	 2N3962, 2N3963 2N3964, 2N3965	h_{fe}	 100 250	 550 700	 — —
Magnitude of Forward Current Transfer Ratio, Common-Emitter (I_C = 0.5 mA, V_{CE} = 5.0 V, f = 200 MHz)	 2N3962, 2N3963 2N3964, 2N3965	$\|h_{fe}\|$	 2.0 2.5	 8.0 8.0	 — —
Output Admittance (I_C = 1.0 mA, V_{CE} = 5.0, f = 1.0 kHz)	 2N3962, 2N3963 2N3964, 2N3965	h_{oe}	 5.0 5.0	 40 50	μmhos
Noise Figure (I_C = 20 mA, V_{CE} = 5.0 V, BW = 15.7 kHz)	 2N3962, 2N3963 2N3964, 2N3965	NF	 — —	 3 2	dB
(I_C = 20 μA, V_{CE} = 5.0 V, BW = 1.5 kHz, f = 10 kHz, R_S = 10 kΩ)	2N3962, 2N3963 2N3964, 2N3965		— —	3 2	
(I_C = 20 μA, V_{CE} = 5.0 V, BW = 150 Hz, f = 1.0 kHz, R_S = 10 kΩ)	2N3962, 2N3963 2N3964, 2N3965		— —	3 2	
(I_C = 20 μA, V_{CE} = 5.0 V, BW = 15 Hz, f = 100 Hz, R_S = 10 kΩ)	2N3962, 2N3963 2N3964, 2N3965		— —	10 4	
(I_C = 20 μA, V_{CE} = 5.0 V, BW = 2.0 Hz, f = 10 Hz, R_S = 10 kΩ)	2N3964, 2N3965		—	8	

(1) Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2%.

4

4

2N4013
2N4014

CASE 22, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N4013	2N4014	Unit
Collector-Emitter Voltage	V_{CEO}	30	50	Vdc
Collector-Base Voltage	V_{CBO}	50	80	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous — Peak	I_C	1.0 2.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 28.6		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.4 6.8		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1)		$V_{(BR)CEO}$				Vdc
(I_C = 10 mAdc, I_B = 0)	2N4014		50	—	—	
	2N4013		30	—	—	
Collector-Emitter Breakdown Voltage		$V_{(BR)CES}$				Vdc
(I_C = 10 μAdc, V_{BE} = 0)	2N4014		80	—	—	
	2N4013		50	—	—	
Collector-Base Breakdown Voltage		$V_{(BR)CBO}$				Vdc
(I_C = 10 μAdc, I_E = 0)	2N4014		80	—	—	
	2N4013		50	—	—	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 60 Vdc, I_E = 0)	2N4014		—	0.12	1.7	
(V_{CB} = 40 Vdc, I_E = 0)	2N4013		—	0.12	1.7	
(V_{CB} = 60 Vdc, I_E = 0, T_A = 100°C)	2N4014		—	—	120	
(V_{CB} = 40 Vdc, I_E = 0, T_A = 100°C)	2N4013		—	—	120	
Collector Cutoff Current		I_{CES}				μAdc
(V_{CE} = 80 Vdc, V_{EB} = 0)	2N4014		—	0.15	10	
(V_{CE} = 50 Vdc, V_{EB} = 0)	2N4013		—	0.15	10	
ON CHARACTERISTICS(1)						
DC Current Gain		h_{FE}				—
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)			30	—	—	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)			60	—	150	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C)			30	—	—	
(I_C = 300 mAdc, V_{CE} = 1.0 Vdc)			40	—	—	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)			35	—	—	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C)			20	—	—	
(I_C = 800 mAdc, V_{CE} = 2.0 Vdc)	2N4014		20			
	2N4013		25	—	—	
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	2N4014		25			
	2N4013		30	—	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	2N4014		—	0.17	0.25	
	2N4013		—	0.17	0.25	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N4014		—	0.19	0.26	
	2N4013		—	0.19	0.20	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
(I_C = 300 mAdc, I_B = 30 mAdc)	2N4014		—	0.25	0.40	
	2N4013		—	0.25	0.32	
(I_C = 500 mAdc, I_B = 50 mAdc)	2N4014		—	0.30	0.52	
	2N4013		—	0.30	0.42	
(I_C = 800 mAdc, I_B = 80 mAdc)	2N4014		—	0.43	0.80	
	2N4013		—	0.43	0.65	
(I_C = 1.0 Adc, I_B = 100 mAdc)	2N4014		—	0.55	0.95	
	2N4013		—	0.55	0.75	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			—	—	0.76	
(I_C = 100 mAdc, I_B = 10 mAdc)			—	—	0.86	
(I_C = 300 mAdc, I_B = 30 mAdc)			—	—	1.1	
(I_C = 500 mAdc, I_B = 50 mAdc)			0.8	—	1.1	
(I_C = 800 mAdc, I_B = 80 mAdc)			—	—	1.5	
(I_C = 1.0 Adc, I_B = 100 mAdc)			—	—	1.7	

SMALL-SIGNAL CHARACTERISTICS

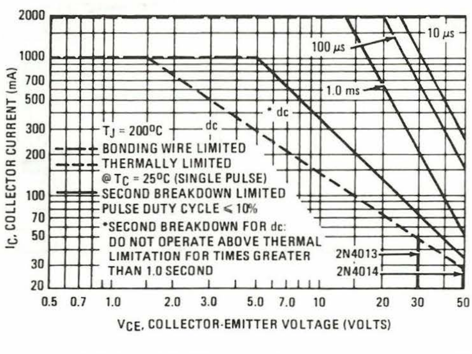
Characteristic		Symbol	Min	Typ	Max	Unit
Current-Gain — Bandwidth Product(2) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	300	—	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	2N4014	C_{obo}	—	—	10	pF
	2N4013		—	—	12	
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	—	55	pF

SWITCHING CHARACTERISTICS

Characteristic	Conditions		Symbol	Min	Typ	Max	Unit
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 3.8 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc) (Figures 8, 10)		t_d	—	5.0	10	ns
Rise Time			t_r	—	15	30	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc) (Figures 9, 10)		t_s	—	30	50	ns
Fall Time		2N4014	t_f	—	20	25	ns
		2N4013			25	30	
Turn-On Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 3.8 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc) (Figures 8, 10)		t_{on}	—	20	35	ns
Turn-Off Time	(V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc) (Figures 9, 10)	2N4014 2N4013	t_{off}	—	50	60	ns

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 1.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$.

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



TYPICAL DC CHARACTERISTICS

FIGURE 2 – DC CURRENT GAIN

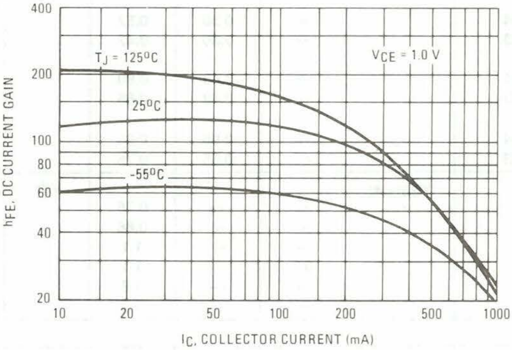


FIGURE 3 – "ON" VOLTAGES

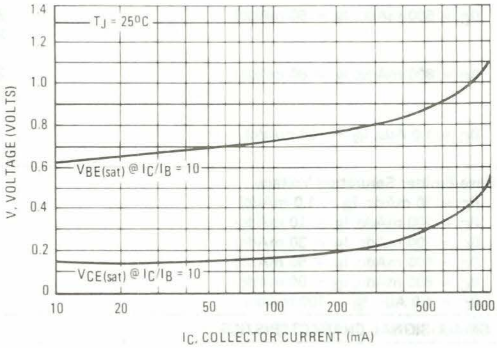


FIGURE 4 – COLLECTOR SATURATION REGION

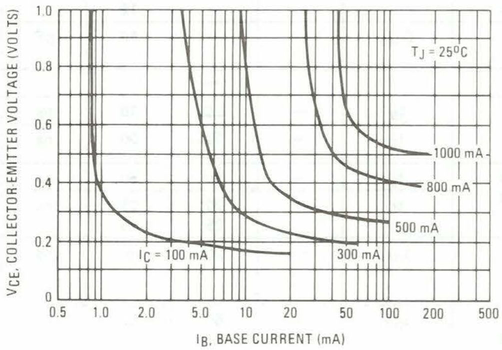
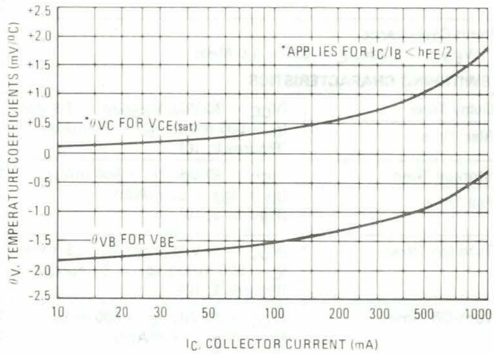


FIGURE 5 – TEMPERATURE COEFFICIENTS



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 6 – CURRENT-GAIN – BANDWIDTH PRODUCT

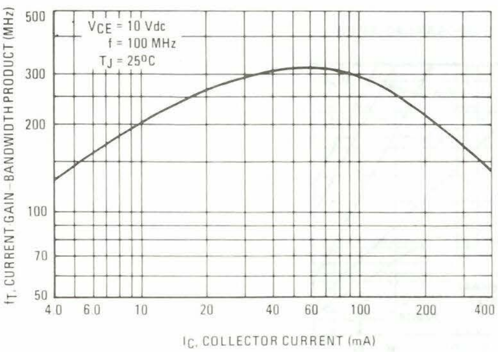


FIGURE 7 – CAPACITANCE

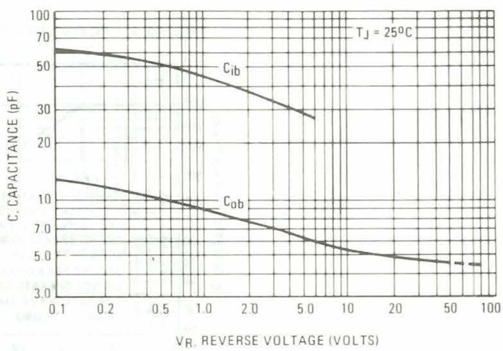


FIGURE 8 – TURN-ON TIME

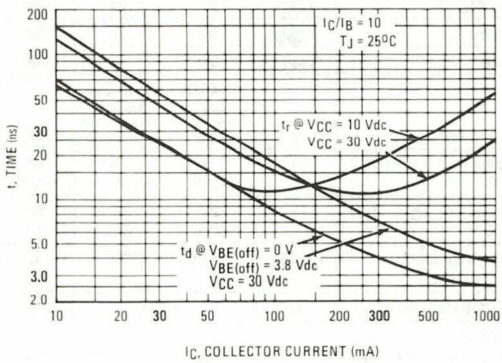


FIGURE 9 – TURN-OFF TIME

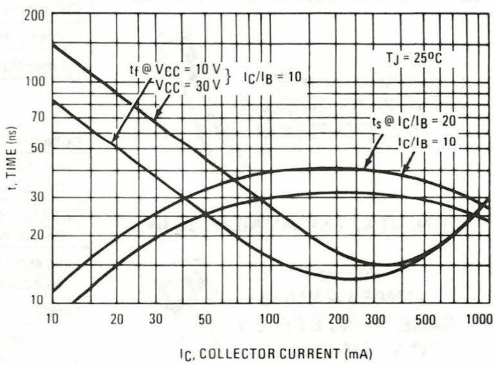
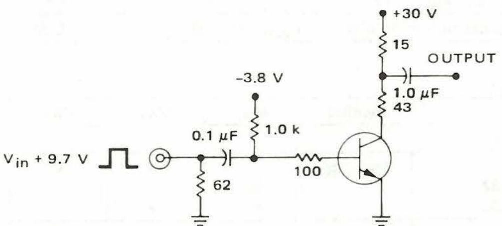
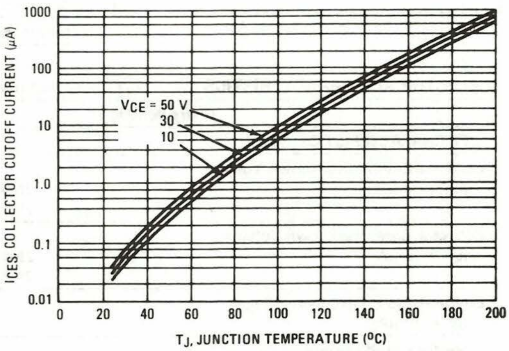


FIGURE 10 – SWITCHING TIME TEST CIRCUIT

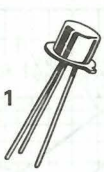


$t_r \leq 1.0$ ns
P.W. $\geq$ 200 ns
Duty Cycle $\leq$ 2.0%
Generator Source Impedance = 50 Ω
Pulse Generator: EH1421 Timing Unit and 1121 Pulse Driver
Oscilloscope: Tektronix 661 Sampling Scope

FIGURE 11 – COLLECTOR CUTOFF CURRENT

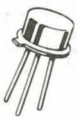


2N4026 thru 2N4033



2N4026–2N4029
CASE 22-03, STYLE 1
TO-18 (TO-206AA)

JAN, JTX, TXV AVAILABLE IN



2N4033
2N4030–2N4033
CASE 79-02, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR
PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N4026/28 2N4030/32	2N4027/29 2N4031/33	Unit
Collector-Emitter Voltage(1)	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	5.0	Vdc
		2N4026-2N4029	2N4030-2N4033	
Collector Current — Continuous	I_C	1.0	1.0	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	.5 2.85	1.25 7.15	W mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.0 11.4	7.0 40	W mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C
Lead or Terminal Temperature(2)	T_L	+300		°C

(1) Applicable 0 to 10 mA
(2) Measured at a distance not less than 1/16″ from seated surface (or case) for 60 Sec.

THERMAL CHARACTERISTICS

Characteristic	Symbol	TO-18	TO-39	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	40	20	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	280	140	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10$ mA)	 2N4026,28,30,32 2N4027,29,31,33	$V_{(BR)CEO}$	 60 80	 — —	V
Collector-Base Breakdown Voltage ($I_C = 10\ \mu A$)	 2N4026,28,30,32 2N4027,29,31,33	$V_{(BR)CBO}$	 60 80	 — —	V
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu A$)		$V_{(BR)EBO}$	5.0	—	V
Collector Cutoff Current ($V_{CB} = 50$ V) ($V_{CB} = 60$ V) ($V_{CB} = 50$ V, $T_A = 150°C$) ($V_{CB} = 60$ V, $T_A = 150°C$)	 2N4026,28,30,32 2N4027,29,31,33 2N4026,28,30,32 2N4027,29,31,33	I_{CBO}	 — — — —	 50 50 50 50	nA μA
Emitter Cutoff Current ($V_{EB} = 5.0$ V)		I_{EBO}	—	10	μA
ON CHARACTERISTICS					
DC Current Gain ($I_C = 100$ mA, $V_{CE} = 5.0$ V, @ −55°C)	 2N4026,27,30,31 2N4028,29,32,33	h_{FE}	 15 40	 — —	—
($I_C = 100\ \mu A$, $V_{CE} = 5.0$ V)	2N4026,27,30,31 2N4028,29,32,33		30 75	— —	
($I_C = 100$ mA, $V_{CE} = 5.0$ V)	2N4026,27,30,31 2N4028,29,32,33		40 100	120 300	
($I_C = 500$ mA, $V_{CE} = 5.0$ V)	2N4026,27,30,31 2N4028,29,32,33		25 70	— —	
($I_C = 1.0$ A, $V_{CE} = 5.0$ V)	2N4026,30 2N4027,31 2N4028,32 2N4029,33		15 10 40 25	— — — —	

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

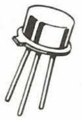
Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			V
(I_C = 150 mA, I_B = 15 mA)			—	0.15	
(I_C = 500 mA, I_B = 50 mA)			—	0.50	
(I_C = 1.0 A, I_B = 100 mA)	2N4026,28,30,32		—	1.0	
Base-Emitter Saturation Voltage (I_C = 150 mA, I_B = 15 mA)		$V_{BE(sat)}$	—	0.9	V
Base-Emitter On Voltage		$V_{BE(on)}$			V
(I_C = 1.0 A, V_{CE} = 1.0 V)	2N4026,28,30,32		—	1.2	
(I_C = 500 mA, V_{CE} = 0.5 V)			—	1.1	
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CE} = 10 V, f = 1.0 MHz)		C_{obo}	—	20	pF
Input Capacitance (V_{EB} = 0.5 V, f = 1.0 MHz)		C_{ibo}	—	110	pF
Small Signal Current Gain (I_C = 50 mA, V_{CE} = 10 V, f = 100 MHz)		h_{fe}	1.0	4.0	—
SWITCHING CHARACTERISTICS					
Storage Time (I_C = 500 mA, I_{B1} = I_{B2} = 50 mA)		t_s	—	350	ns
Turn-On Time (I_C = 500 mA, I_{B1} = 50 mA)		t_{on}	—	100	ns
Fall Time (I_C = 500 mA, I_{B1} = I_{B2} = 50 mA)		t_f	—	50	ns

(3) Pulse Width = 300 μs, Duty Cycle 1.0%.

4

2N4036
2N4037

CASE 79-02, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	2N4036	2N4037	Unit
Collector-Emitter Voltage	V_{CEO}	65	40 (sus)(1)	Vdc
Collector-Base Voltage	V_{CBO}	90	60	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	7.0	Vdc
Base Current	I_B	0.5		Adc
Collector Current — Continuous	I_C	1.0		Adc
Continuous Power Dissipation at or Below $T_C = 25°C$ Linear Derating Factor	P_D	 5.0 28.6	 1.0 5.72	 Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C
Lead Temperature 1/16″ from Case for 10 Seconds	T_L	230		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N4036	2N4037	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	25	—	°C/W

(1) Must not be tested on a curve tracer.

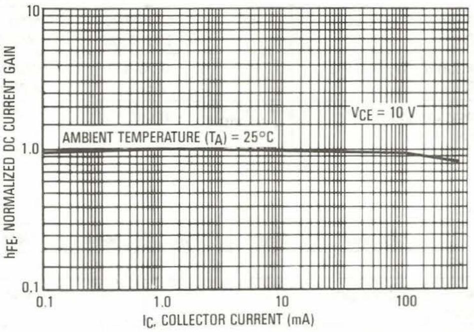
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage ($I_C = 100$ mAdc, $I_B = 0$)	 2N4036 2N4037	$V_{CEO(sus)}$	 65 40	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mA dc)	 2N4037	$V_{(BR)CBO}$	60	—	Vdc
Collector Cutoff Current ($V_{CE} = 85$ V, $V_{BE} = 1.5$ V) ($V_{CE} = 30$ V, $V_{BE} = 1.5$ V, $T_C = 150°C$)	 2N4036	I_{CEX}	 —	 100 0.1	mAdc
Collector Cutoff Current ($V_{CB} = 90$ V, $I_E = 0$) ($V_{CB} = 60$ V, $I_E = 0$)	 2N4036 2N4037	I_{CBO}	 —	 100 0.25	μAdc
Emitter Cutoff Current ($V_{BE} = 7.0$ Vdc, $I_C = 0$) ($V_{BE} = 5.0$ Vdc, $I_C = 0$)	 2N4036 2N4037	I_{EBO}	 — —	 10.0 1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 150$ mAdc, $V_{CE} = 2.0$ V) ($I_C = 0.1$ mAdc, $V_{CE} = 10$ V) ($I_C = 1.0$ mAdc, $V_{CE} = 10$ V) ($I_C = 150$ mAdc, $V_{CE} = 10$ V) ($I_C = 500$ mAdc, $V_{CE} = 10$ V)	 2N4036 2N4036 2N4037 2N4036 2N4037 2N4036	h_{FE}	 20 20 15 40 50 20	 200 — — 140 250 —	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mA, $I_B = 15$ mA)	 2N4036 2N4037	$V_{CE(sat)}$		 0.65 1.4	V
Base-Emitter Saturation Voltage ($I_C = 150$ mA, $I_B = 15$ mA)	 2N4036	$V_{BE(sat)}$		1.4	V
Base-Emitter On Voltage ($I_C = 150$ mA, $V_{CE} = 10$ V)	 2N4037	$V_{BE(on)}$		1.5	V
SMALL-SIGNAL CHARACTERISTICS					
Collector-Base Capacitance ($V_{CB} = 10$ V, f = 1.0 MHz)	 2N4037	C_{cb}	—	30	pF
Current Gain — High Frequency ($I_C = 50$ mA, $V_{CE} = 10$ V, f = 20 MHz)	 2N4036 2N4037	$\lvert h_{fe} \rvert$	 3.0 3.0	 — 10.0	—

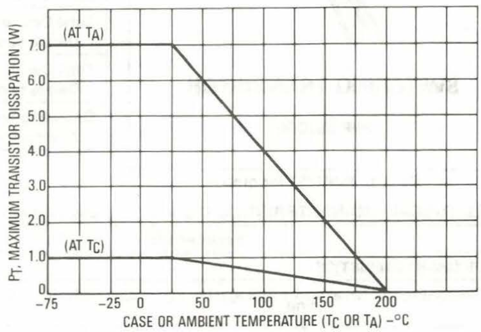
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS					
Rise Time (I_{B1} = 15 mA)	2N4036	t_r	—	70	ns
Storage Time (I_{B2} = 15 mA)	2N4036	t_s	—	600	ns
Fall Time (I_{B2} = 15 mA)	2N4036	t_f	—	100	ns
Turn-On Time (I_{B1} = I_{B2})	2N4036	t_{on}	—	110	ns
Turn-Off Time (I_{B1} = I_{B2})	2N4036	t_{off}	—	700	ns

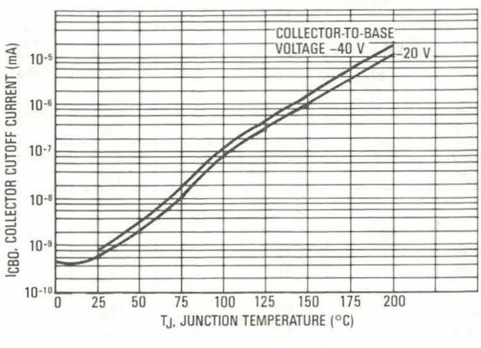
CURRENT GAIN CHARACTERISTICS versus COLLECTOR-EMITTER VOLTAGE



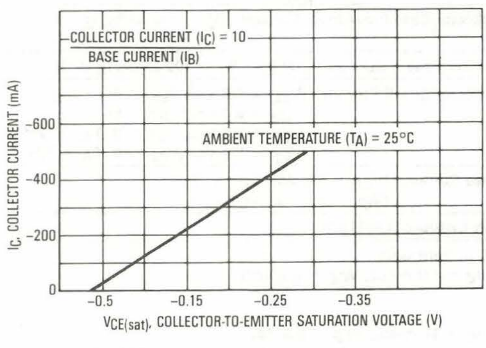
DISSIPATION DERATING CURVE



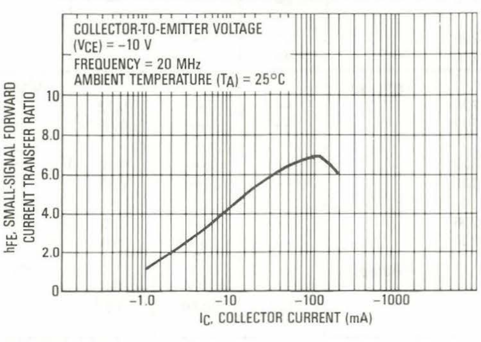
TYPICAL COLLECTOR-CUTOFF CURRENT versus JUNCTION TEMPERATURE



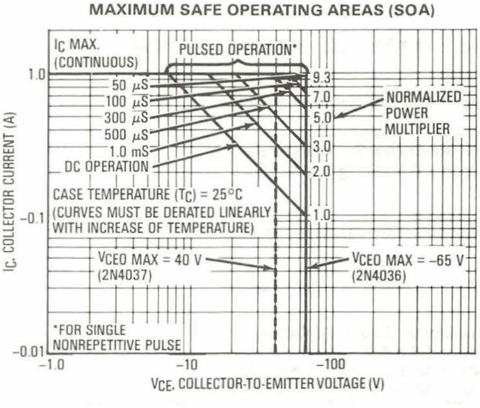
TYPICAL SATURATION-VOLTAGE CHARACTERISTICS



TYPICAL SMALL SIGNAL BETA CHARACTERISTICS



MAXIMUM SAFE OPERATING AREAS (SOA)



2N4208
2N4209

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

PNP SILICON

Refer to MM4257 for graphs.

4

MAXIMUM RATINGS

Rating	Symbol	2N4208	2N4209	Unit
Collector-Emitter Voltage	V_{CEO}	12	15	Vdc
Collector-Base Voltage	V_{CBO}	12	15	Vdc
Emitter-Base Voltage	V_{EBO}	4.5		Vdc
Collector Current — Continuous	I_C	50–200		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.30–0.36 1.72–2.06		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.70–1.2 4.0–6.9		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 3.0 mAdc, I_B = 0)	2N4208 2N4209	$V_{(BR)CEO}$	12 15	— —	— —	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	2N4208 2N4209	$V_{(BR)CES}$	12 15	— —	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N4208 2N4209	$V_{(BR)CBO}$	12 15	— —	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	4.5	5.9	—	Vdc
Collector Cutoff Current (V_{CE} = 6.0 Vdc, V_{BE} = 0) (V_{CE} = 8.0 Vdc, V_{BE} = 0) (V_{CE} = 6.0 Vdc, V_{BE} = 0, T_A = 125°C) (V_{CE} = 8.0 Vdc, V_{BE} = 0, T_A = 125°C)	2N4208 2N4209 2N4208 2N4209	I_{CES}	— — — —	— — — —	10 10 5.0 5.0	nAdc μAdc
Base Current (V_{CE} = 6.0 Vdc, V_{BE} = 0) (V_{CE} = 8.0 Vdc, V_{BE} = 0)	2N4208 2N4209	I_B	— —	— —	1.0 1.0	nAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				—
(I_C = 1.0 mAdc, V_{CE} = 0.5 Vdc)	2N4208 2N4209		15 35	— —	— —	
(I_C = 10 mAdc, V_{CE} = 0.3 Vdc)	2N4208 2N4209		30 50	— —	120 120	
(I_C = 10 mAdc, V_{CE} = 0.3 Vdc, T_A = −55°C)	2N4208 2N4209		12 20	— —	— —	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)(1)	2N4208 2N4209		30 40	— —	— —	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 1.0 mAdc, I_B = 0.1 mAdc)	2N4208 2N4209		— —	— —	0.13 0.15	
(I_C = 10 mAdc, I_B = 1.0 mAdc)	2N4208 2N4209		— —	— —	0.15 0.18	
(I_C = 50 mAdc, I_B = 5.0 mAdc)(1)	2N4208 2N4209		— —	— —	0.5 0.6	
Base-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)(1)		$V_{BE(sat)}$	 — 0.75 —	 0.7 0.86 1.1	 0.8 0.90 1.5	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

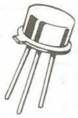
Characteristic		Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N4208	f_T	700	1000	—	MHz
	2N4209		850	1100	—	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)		C_{obo}	—	2.0	3.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)		C_{ibo}	—	2.0	3.5	pF
SWITCHING CHARACTERISTICS						
Turn-On Time	(V_{CC} = 1.5 Vdc, V_{BE} = 0, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_{on}	—	10	15	ns
Delay Time		t_d	—	5.0	10	ns
Rise Time		t_r	—	5.0	15	ns
Turn-Off Time	(V_{CC} = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc) 2N4208	t_{off}	—	12	15	ns
	2N4209		—	16	20	
Storage Time	2N4208	t_s	—	12	15	ns
	2N4209		—	17	20	
Fall Time	2N4208	t_f	—	6.0	10	ns
	2N4209			8.0	10	
Storage Time (I_C ≈ 10 mAdc, I_{B1} ≈ 10 mAdc, I_{B2} ≈ 10 mAdc)	2N4208	t_s	—	—	15	ns
	2N4209		—	—	20	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

4

2N4234
2N4235
2N4236

CASE 79-02, STYLE 1
TO-39 (TO-205AD)



POWER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	2N4234	2N4235	2N4236	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CBO}	40	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	7.0			Vdc
Base Current	I_B	0.2			Vdc
Collector Current — Continuous	I_C	1.0 3.0*			Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.7			Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	6.0 34			Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	29	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

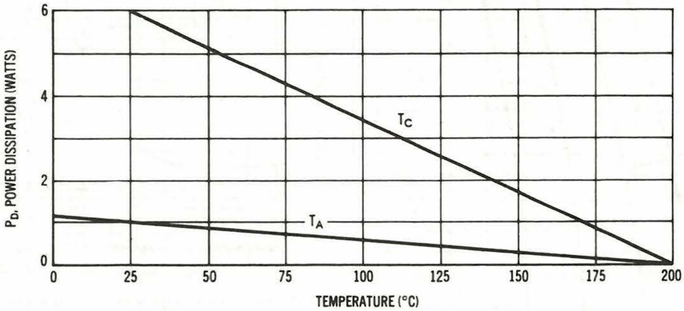
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) (I_C = 100 mAdc, I_B = 0)	2N4234 2N4235 2N4236	$V_{CEO(sus)}$	40 60 80	— — —	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0) (V_{CE} = 40 Vdc, I_B = 0) (V_{CE} = 60 Vdc, I_B = 0)	 2N4234 2N4235 2N4236	I_{CEO}	 — — —	 1.0 1.0 1.0	mAdc
Collector Cutoff Current (V_{CE} = 40 Vdc, V_{BE} = 1.5 Vdc) (V_{CE} = 60 Vdc, V_{BE} = 1.5 Vdc) (V_{CE} = 80 Vdc, V_{BE} = 1.5 Vdc) (V_{CE} = 30 Vdc, V_{BE} = 1.5 Vdc, T_C = 150°C) (V_{CE} = 40 Vdc, V_{BE} = 1.5 Vdc, T_C = 150°C) (V_{CE} = 60 Vdc, V_{BE} = 1.5 Vdc, T_C = 150°C)	 2N4234 2N4235 2N4236 2N4234 2N4235 2N4236	I_{CEX}	 — — — — — —	 0.1 0.1 0.1 1.0 1.0 1.0	mAdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 80 Vdc, I_E = 0)	 2N4234 2N4235 2N4236	I_{CBO}	 — — —	 0.1 0.1 0.1	mAdc
Emitter Cutoff Current (V_{BE} = 7 Vdc, I_C = 0)		I_{EBO}	—	0.5	mAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 250 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)		h_{FE}	 40 30 20 10	 — 150 — —	—
Collector-Emitter Saturation Voltage(1) (I_C = 1.0 Adc, I_B = 125 mAdc)		$V_{CE(sat)}$	—	0.6	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 1.0 Adc, I_B = 100 mAdc)		$V_{BE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage (I_C = 250 mAdc, V_{CE} = 1.0 Vdc)		V_{BE}	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	3.0	—	MHz

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	100	pF
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	25	—	—

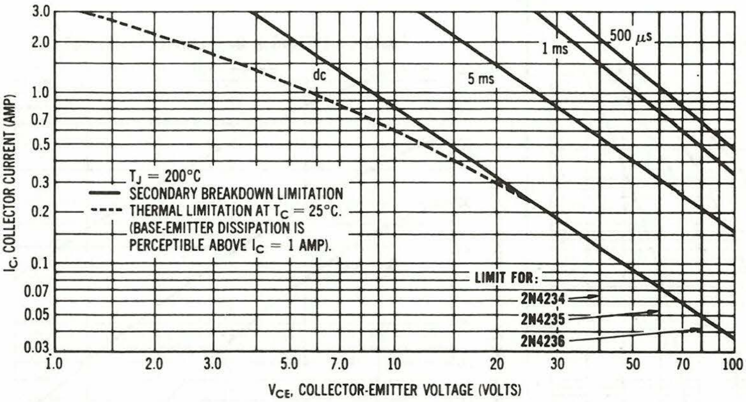
(1) Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2.0%.
*Indicates Data in addition to JEDEC Requirements.

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 2.
All limits are applicable and must be observed.

FIGURE 2 — ACTIVE-REGION SAFE OPERATING AREAS



The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

4

LARGE SIGNAL CHARACTERISTICS

FIGURE 3 — TRANSCONDUCTANCE

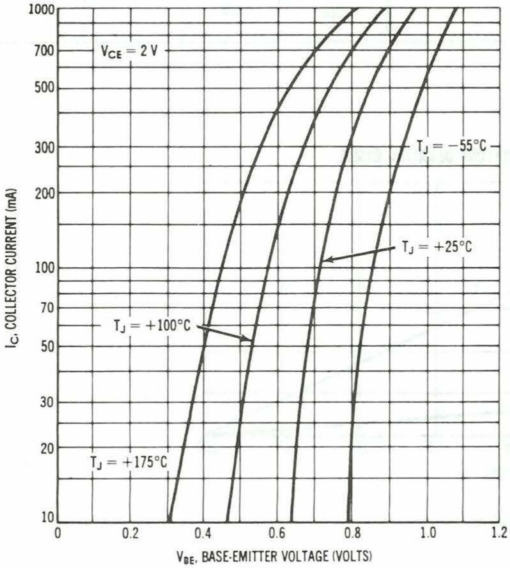
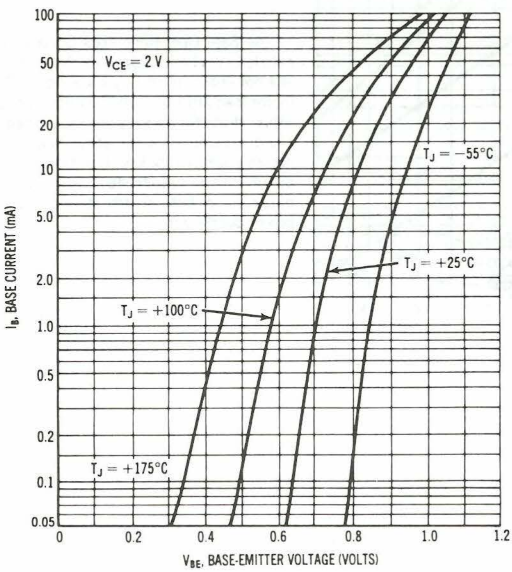


FIGURE 4 — INPUT ADMITTANCE



"OFF" REGION CHARACTERISTICS

FIGURE 5 — TRANSCONDUCTANCE

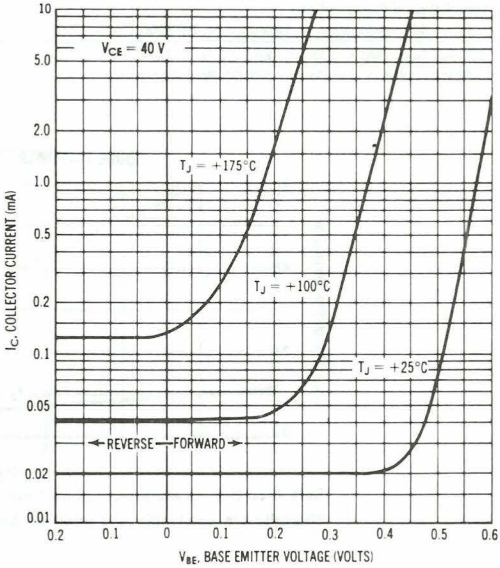


FIGURE 6 — EFFECTS OF BASE-EMITTER RESISTANCE

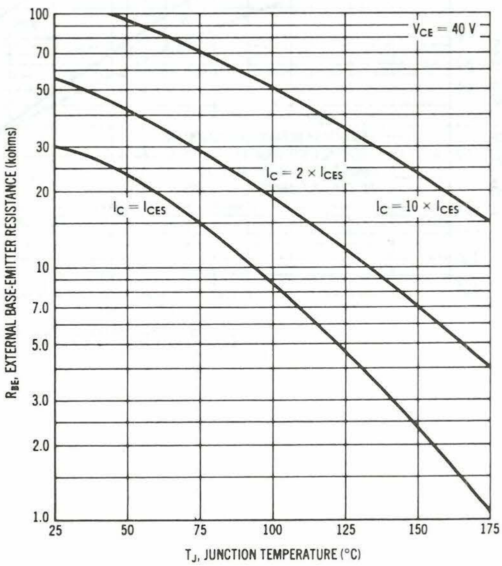
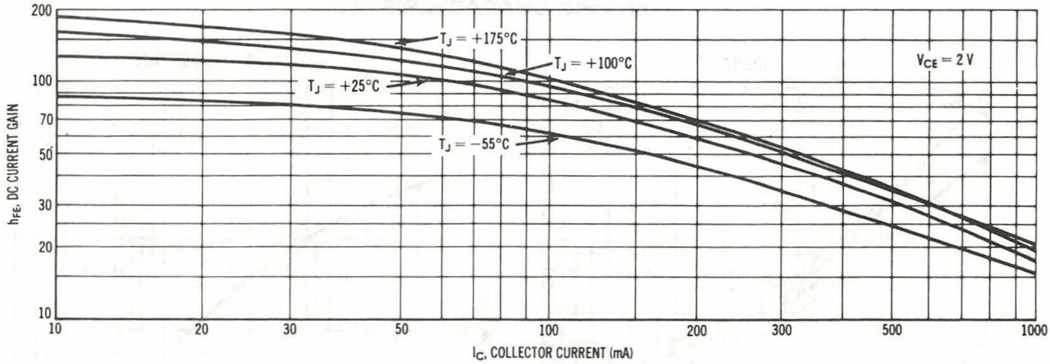


FIGURE 7 — CURRENT GAIN



SATURATION REGION CHARACTERISTICS

FIGURE 8 — COLLECTOR SATURATION REGION

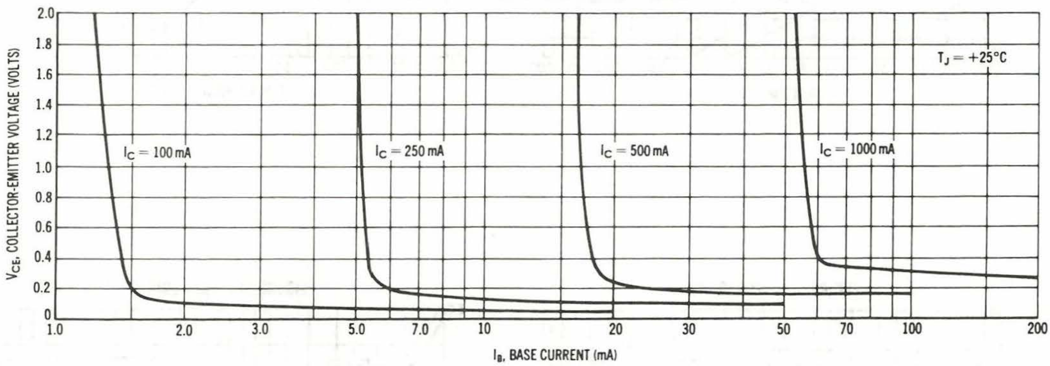


FIGURE 9 — "ON" VOLTAGES

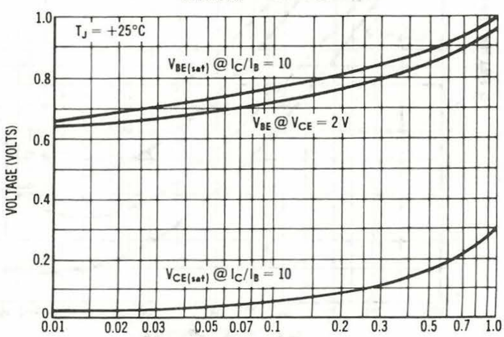
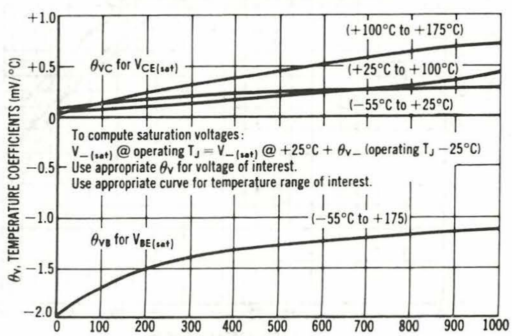


FIGURE 10 — TEMPERATURE COEFFICIENTS



4

DYNAMIC CHARACTERISTICS

FIGURE 11 — TURN-ON TIME

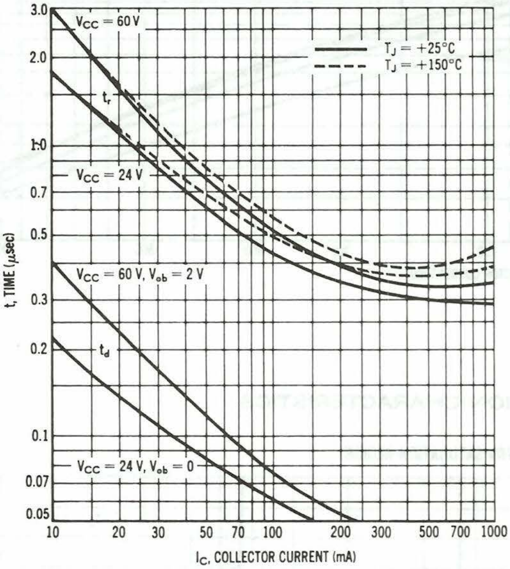


FIGURE 13 — CAPACITANCE

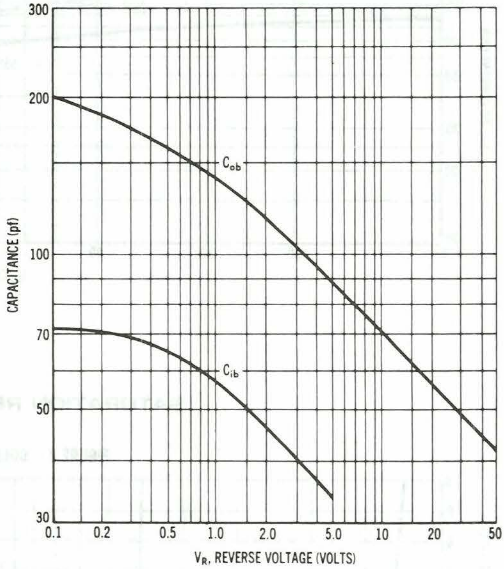


FIGURE 12 — STORAGE TIME

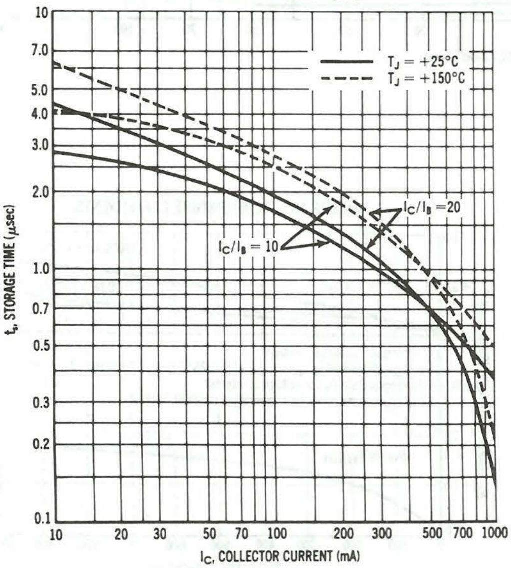
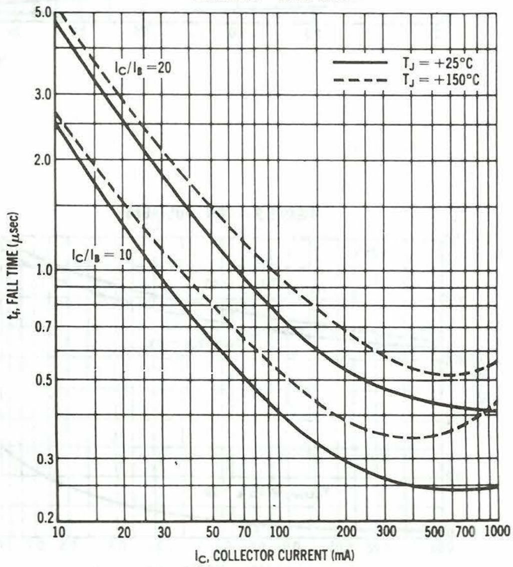
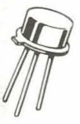


FIGURE 14 — FALL TIME



2N4237
2N4238
2N4239

CASE 79-02, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N4237	2N4238	2N4239	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CBO}	50	80	100	Vdc
Emitter-Base Voltage	V_{EBO}		6.0		Vdc
Base Current	I_B		500		Vdc
Collector Current — Continuous	I_C		1.0 3.0*		Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D		1.0 5.3		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D		6.0 34		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Thermal Resistance, Junction to Case	$R_{\theta JC}$	29	°C/W

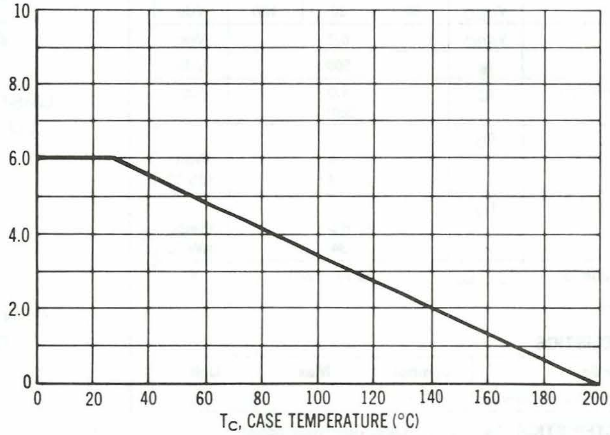
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) ($I_C = 100$ mAdc, $I_B = 0$)	 2N4237 2N4238 2N4239	$V_{CEO(sus)}$	 40 60 80	 — — —	Vdc
Collector Cutoff Current ($V_{CE} = 50$ Vdc, $V_{EB} = 1.5$ Vdc) ($V_{CE} = 80$ Vdc, $V_{EB} = 1.5$ Vdc) ($V_{CE} = 100$ Vdc, $V_{EB} = 1.5$ Vdc) ($V_{CE} = 30$ Vdc, $V_{EB} = 1.5$ Vdc, $T_C = 150°C$) ($V_{CE} = 50$ Vdc, $V_{EB} = 1.5$ Vdc, $T_C = 150°C$) ($V_{CE} = 70$ Vdc, $V_{EB} = 1.5$ Vdc, $T_C = 150°C$)	 2N4237 2N4238 2N4239 2N4237 2N4238 2N4239	I_{CEX}	 — — — — — —	 0.1 0.1 0.1 1.0 1.0 1.0	mAdc
Collector Cutoff Current (V_{CB} = Rated V_{CBO}, $I_E = 0$) (V_{CE} = Rated V_{CEO}, $I_B = 0$)		I_{CBO}	 — —	 0.1 .07	mAdc
Emitter Cutoff Current ($V_{EB} = 6.0$ Vdc, $I_C = 0$)		I_{EBO}	—	0.5	mAdc
ON CHARACTERISTICS					
DC Current Gain(1) ($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 250$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 500$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 1.0$ Adc, $V_{CE} = 1.0$ Vdc)		h_{FE}	 30 30 30 15	 — 150 — —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 500$ mAdc, $I_B = 50$ mAdc) ($I_C = 1.0$ Adc, $I_B = 0.1$ Adc)		$V_{CE(sat)}$	 — —	 0.3 0.6	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 1.0$ Adc, $I_B = 0.1$ Adc)		$V_{BE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage(1) ($I_C = 250$ mAdc, $V_{CE} = 1.0$ Vdc)		$V_{BE(on)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance ($V_{CB} = 10$ Vdc, $I_C = 0$, f = 0.1 MHz)		C_{obo}	—	100	pF
Small Signal Current Gain ($I_C = 100$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)		h_{fe}	30	—	—
Current Gain — High Frequency ($V_{CE} = 10$ V, $I_C = 100$ mA, f = 1 MHz)		$\lvert h_{fe} \rvert$	1.0	—	—

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle 2.0%.
*Indicates Data in addition to JEDEC Requirements.

4

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 5. All limits are applicable and must be observed.

SWITCHING CHARACTERISTICS

FIGURE 2 — SWITCHING TIME EQUIVALENT CIRCUIT

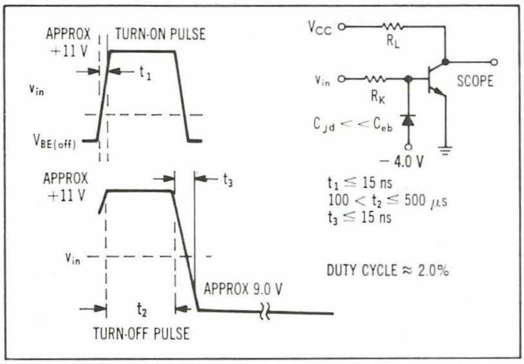


FIGURE 3 — TURN-ON TIME

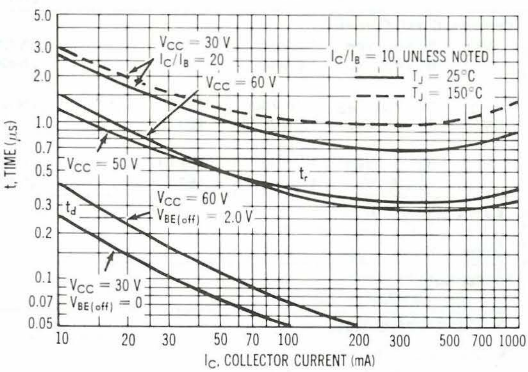


FIGURE 4 — THERMAL RESPONSE

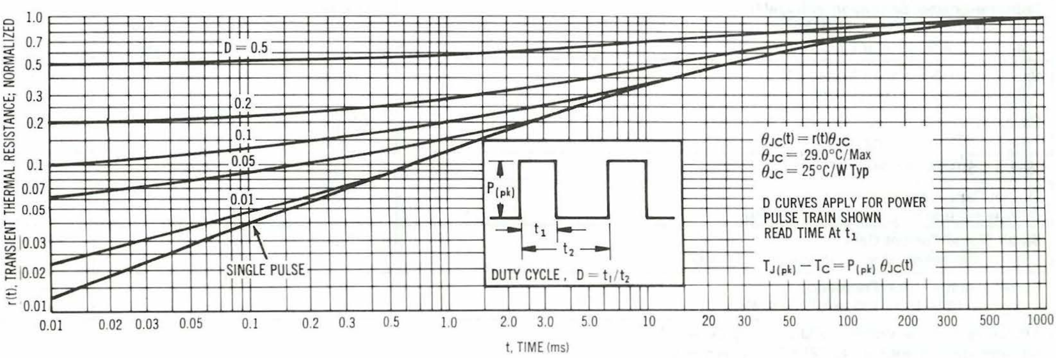
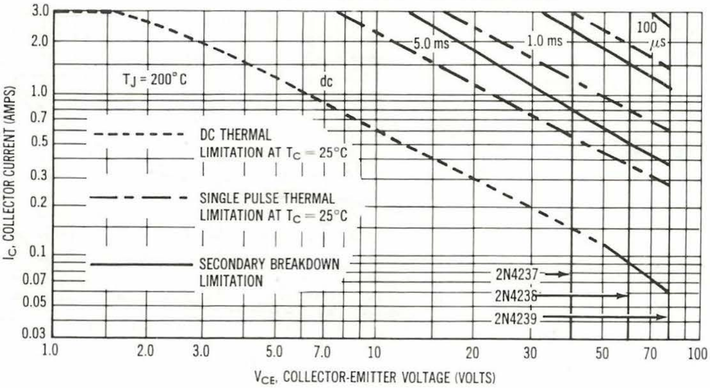


FIGURE 5 — ACTIVE-REGION SAFE OPERATING AREAS



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

For this particular transistor family, the thermal curves are the limiting design values, except for a small portion of the dc curve. The pulse secondary breakdown curves are shown for information only.

4

FIGURE 6 — STORAGE TIME

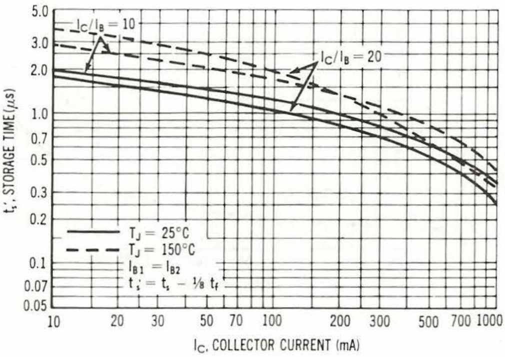
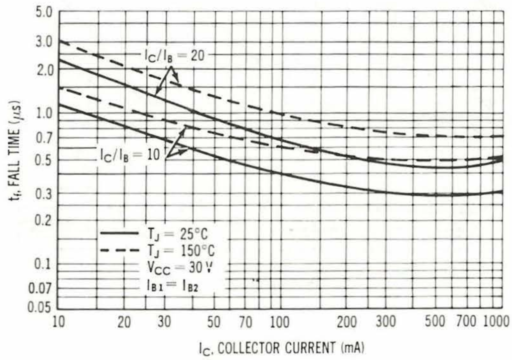


FIGURE 7 — FALL TIME



TYPICAL DC CHARACTERISTICS

FIGURE 8 — CURRENT GAIN

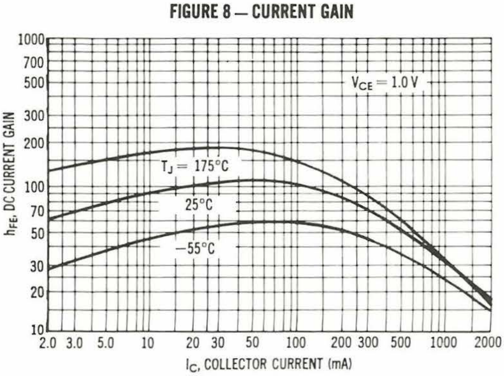
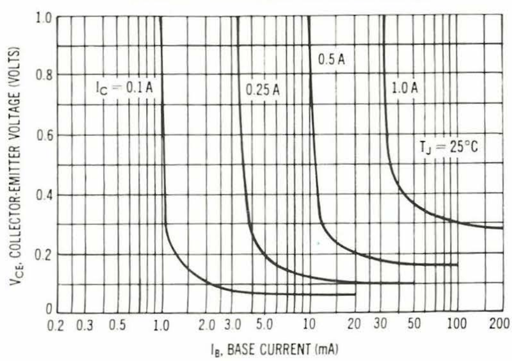


FIGURE 9 — COLLECTOR SATURATION REGION



4

FIGURE 10 — EFFECTS OF BASE-EMITTER RESISTANCE

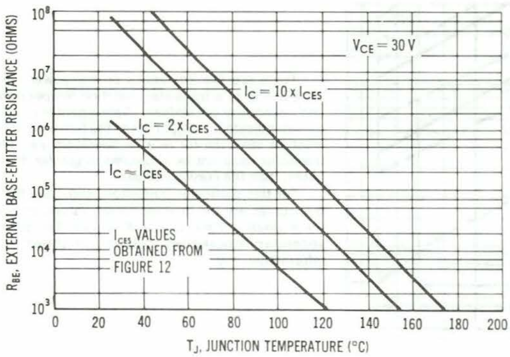


FIGURE 11 — "ON" VOLTAGE

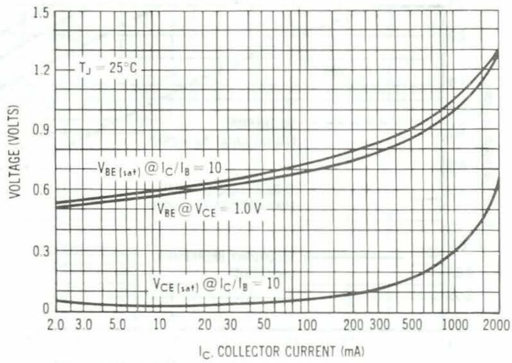


FIGURE 12 — COLLECTOR CUTOFF REGION

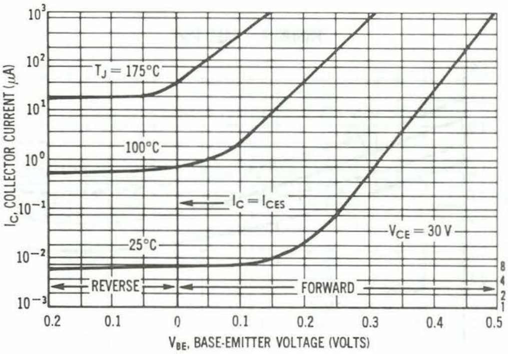
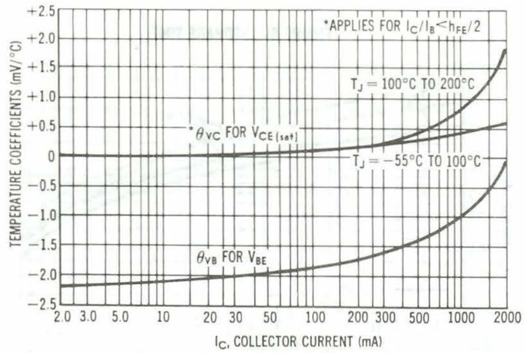


FIGURE 13 — TEMPERATURE COEFFICIENTS



2N4260
2N4261

2N4261 JAN, JTX AVAILABLE
CASE 20, STYLE 10
TO-72

SWITCHING TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	15	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	Vdc
Collector Current — Continuous	I_C	30	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	200 1.14	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_E = 0$)		$V_{(BR)CEO}$	15	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)		$V_{(BR)CBO}$	15	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	4.5	—	Vdc
Collector Cutoff Current ($V_{CE} = 10$ Vdc, $V_{BE(off)} = 2.0$ Vdc) ($V_{CE} = 10$ Vdc, $V_{BE(off)} = 2.0$ Vdc, $T_A = 150°C$) ($V_{CE} = 10$ Vdc, $V_{EB(on)} = 0.4$ Vdc)		I_{CEX}	 — — —	 0.005 5.0 0.05	μAdc
Base Cutoff Current ($V_{CE} = 10$ Vdc, $V_{BE(off)} = 2.0$ Vdc)		I_{BL}	—	0.005	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 2.0$ Vdc)		h_{FE}	 25 30 20	 — 150 —	—
Collector-Emitter Saturation Voltage ($I_C = 1.0$ mAdc, $I_B = 0.1$ mAdc) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)		$V_{CE(sat)}$	 — —	 0.15 0.35	Vdc
Base-Emitter On Voltage ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)		$V_{BE(on)}$	 — —	 0.8 1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 5.0$ mAdc, $V_{CE} = 4.0$ Vdc, f = 100 MHz) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	 2N4260 2N4261 2N4260 2N4261	f_T	 1200 1500 1600 2000	 — — — —	MHz
Output Capacitance ($V_{CB} = 4.0$ Vdc, $I_E = 0$, f = 100 kHz)		C_{obo}	—	2.5	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)		C_{ibo}	—	2.5	pF
Current Gain — High Frequency ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	2N4260 2N4261	$\|h_{fe}\|$	16 20	— —	—

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Collector Base Time Constant		$rb'C_C$			ps
(I_C = 5.0 mAdc, V_{CE} = 4.0 Vdc, f = 31.8 MHz)	2N4260		—	35	
	2N4261		—	60	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 31.8 MHz)	2N4260		—	30	
	2N4261		—	50	

SWITCHING CHARACTERISTICS

Characteristic	Symbol	Typical Performance (v_{out} = 1.0 V) @ 10 mA	Typical Performance (v_{out} = 1.0 V) @ 30 mA	Unit
Rise Time	t_r	0.5	0.9	ns
Fall Time	t_f	1.0	1.2	ns
Turn-On Time	$t_{on(delay)}$	1.0	1.2	ns
Turn-Off Delay Time	$t_{off(delay)}$	1.0	1.2	ns

FIGURE 1 — DC CURRENT GAIN

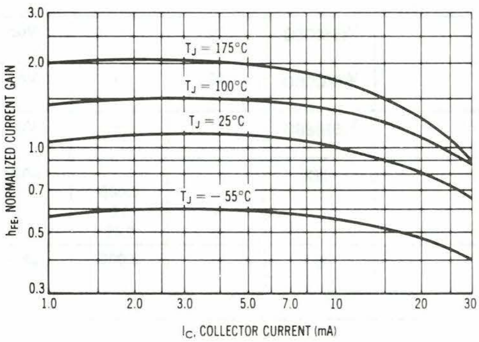


FIGURE 2 — COLLECTOR SATURATION REGION

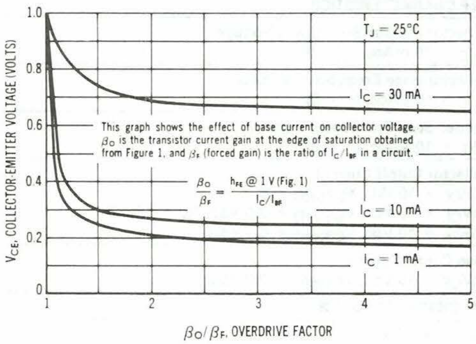


FIGURE 3 — "ON" VOLTAGES

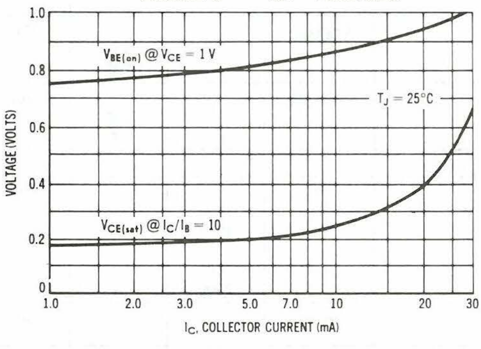


FIGURE 4 — TEMPERATURE COEFFICIENTS

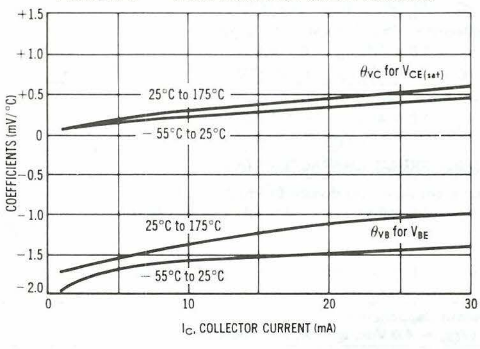


FIGURE 5 — CURRENT-GAIN — BANDWIDTH PRODUCT

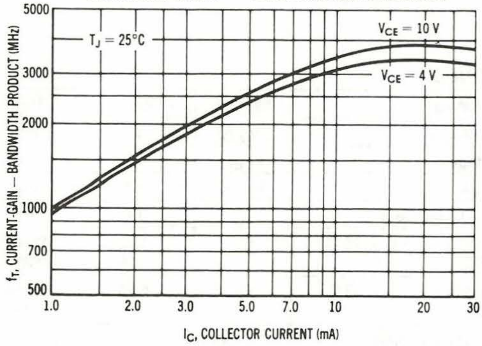
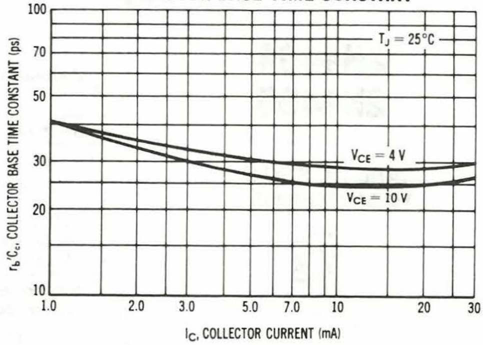
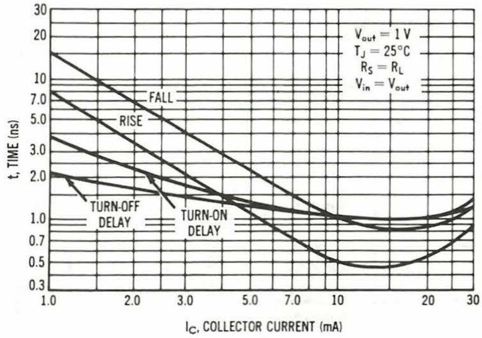


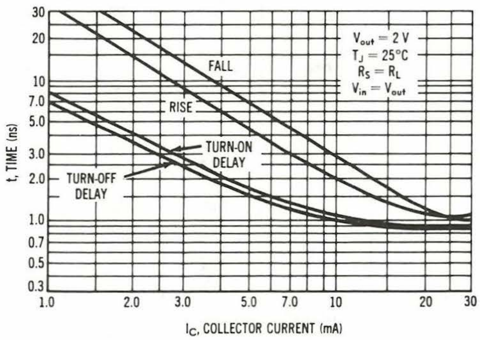
FIGURE 6 — COLLECTOR-BASE TIME CONSTANT

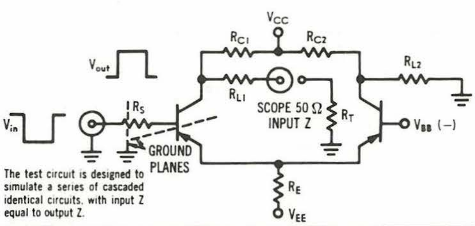


4

FIGURE 7 — SWITCHING TIMES







The test circuit is designed to simulate a series of cascaded identical circuits, with input Z equal to output Z.

$V_{in} = V_{out} = 2$ V $V_{BB} = 1$ V $R_{C1} = R_{C2}$								$V_{in} = V_{out} = 1$ V $V_{BB} = 0.5$ V $R_{C1} = R_{C2}$						
I_C mA	R_S ohms	R_C ohms	R_{L1} ohms	R_{L2} ohms	R_E ohms	V_{EE} volts	V_{CC} volts	R_S ohms	R_C ohms	R_{L1} ohms	R_{L2} ohms	R_E ohms	V_{EE} volts	V_{CC} volts
1	2 k	6 k	3 k	3 k	10 k	10	16	1 k	6 k	1.2 k	1.2 k	24 k	24	32
5	360	3.56 k	400	450	2 k	10	47	175	1 k	200	250	3 k	15	27
10	160	1 k	200	250	3 k	30	26.3	75	300	100	150	3 k	30	17
20	62	300	100	150	1 k	20	16	25	150	25	75	1 k	20	11
30	28	157	66	116	1 k	30	13	8	77	0	50	1 k	30	9

FIGURE 8 — CAPACITANCE

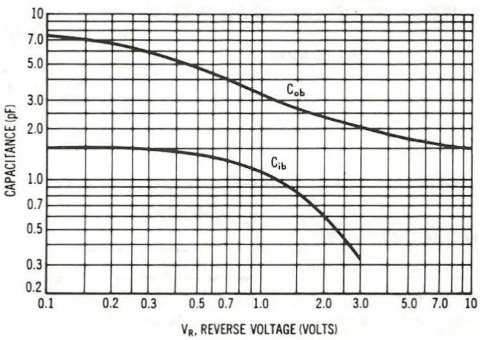
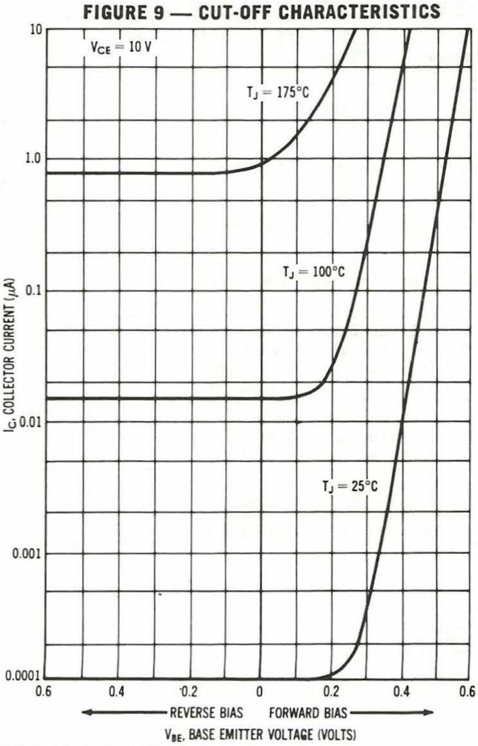
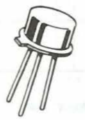


FIGURE 9 — CUT-OFF CHARACTERISTICS



2N4404
2N4405

CASE 79, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Base Voltage	V_{CBO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.25 7.15	Watts mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	8.75 50	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	25	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	140	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	80	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)		$V_{(BR)CBO}$	80	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 60$ Vdc, $I_E = 0$)		I_{CBO}	—	25	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	25	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
($I_C = 0.1$ mAdc, $V_{CE} = 5.0$ Vdc)	2N4404 2N4405		30 75	— —	
($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	2N4404 2N4405		40 100	— —	
($I_C = 150$ mAdc, $V_{CE} = 5.0$ Vdc)(1)	2N4404 2N4405		40 100	120 300	
($I_C = 500$ mAdc, $V_{CE} = 5.0$ Vdc)(1)	2N4404 2N4405		30 50	— —	
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 150$ mAdc, $I_B = 15$ mAdc)(1) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)(1)		$V_{CE(sat)}$	 — — —	 0.15 0.2 0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)(1)		$V_{BE(sat)}$	 — 0.85	 0.8 1.2	Vdc
Base-Emitter On Voltage ($I_C = 150$ mAdc, $V_{CE} = 1.0$ Vdc)		$V_{BE(on)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)		f_T	200	600	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{cb}	—	10	pF
Emitter-Base Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)		C_{eb}	—	75	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc)	t_d	—	15	ns
Rise Time		t_r	—	25	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_s	—	175	ns
Fall Time		t_f	—	35	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 – TURN-ON

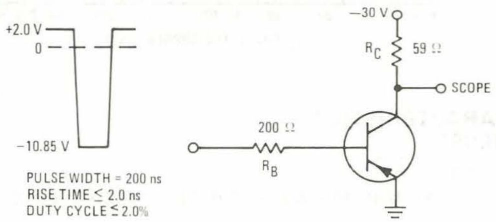
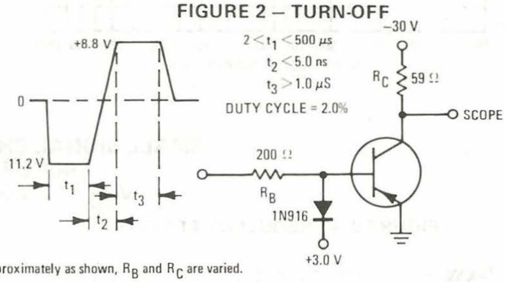


FIGURE 2 – TURN-OFF



To obtain data for curves, voltage levels are approximately as shown, R_B and R_C are varied.

TRANSIENT CHARACTERISTICS

——— 25°C   – – – 100°C

FIGURE 3 – CAPACITANCES

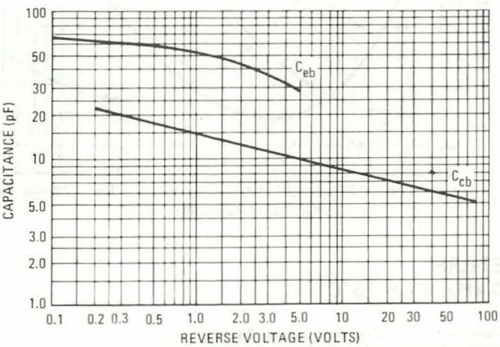


FIGURE 4 – CHARGE DATA

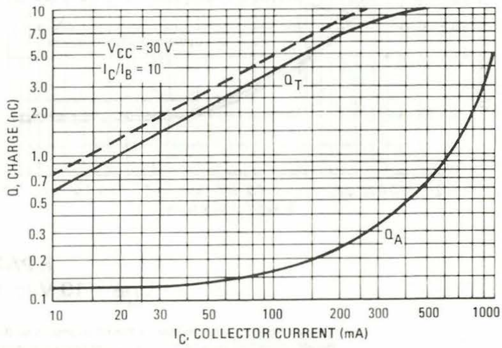


FIGURE 5 – DELAY TIME

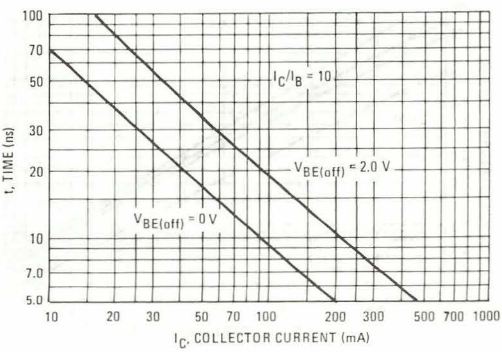


FIGURE 6 – RISE TIME

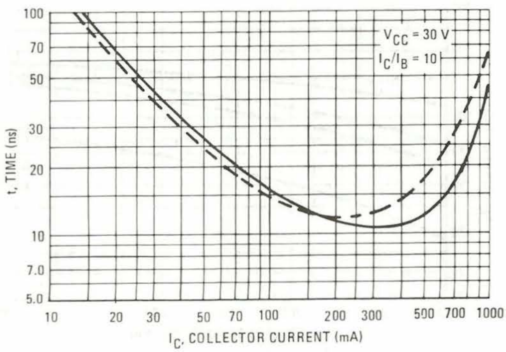


FIGURE 7 — STORAGE TIME

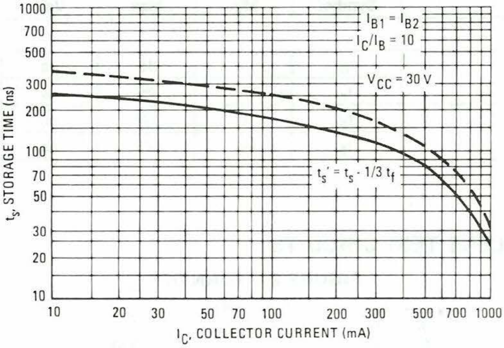
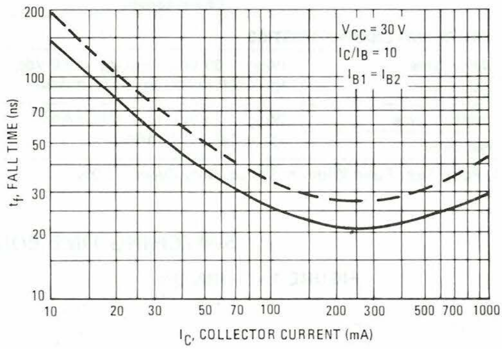


FIGURE 8 — FALL TIME



SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

$V_{CE} = 10$ Vdc, $T_A = 25°C$

FIGURE 9 — FREQUENCY EFFECTS

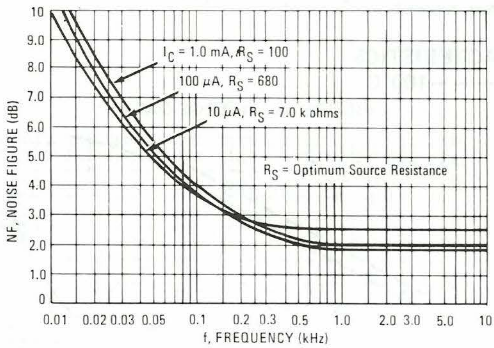
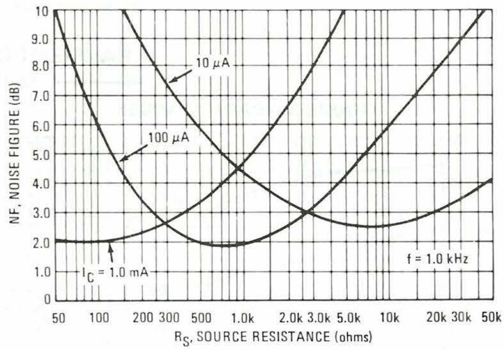


FIGURE 10 — SOURCE RESISTANCE EFFECTS



h PARAMETERS

$V_{CE} = 10$ Vdc, f = 1.0 kHz, $T_A = 25°C$

This group of graphs illustrates the relationship of the "h" parameters for this series of transistors. To obtain these curves, 4 units were selected and identified by number — the same units were used to develop curves on each graph.

FIGURE 11 — CURRENT GAIN

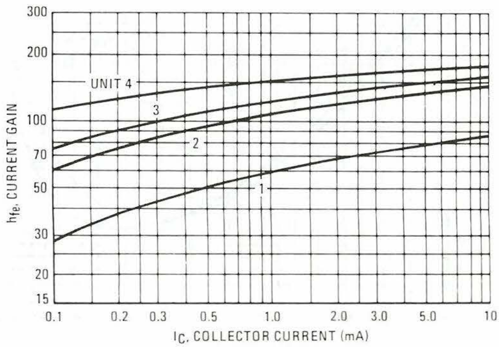


FIGURE 12 — INPUT IMPEDANCE

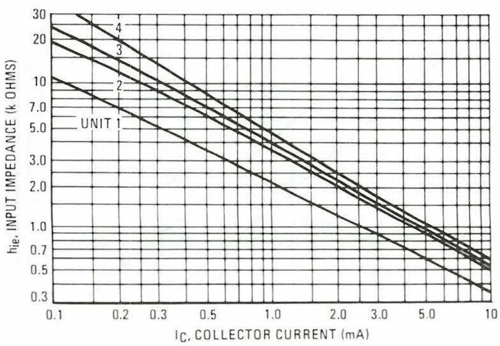


FIGURE 13 — VOLTAGE FEEDBACK RATIO

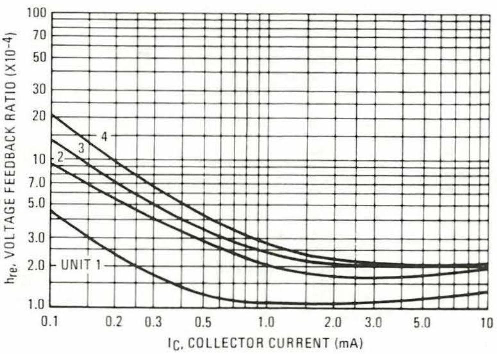
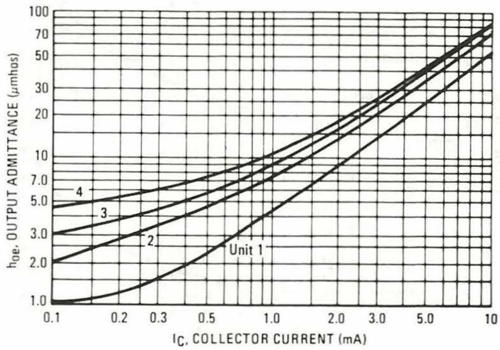


FIGURE 14 — OUTPUT ADMITTANCE



4

STATIC CHARACTERISTICS

FIGURE 15 — DC CURRENT GAIN

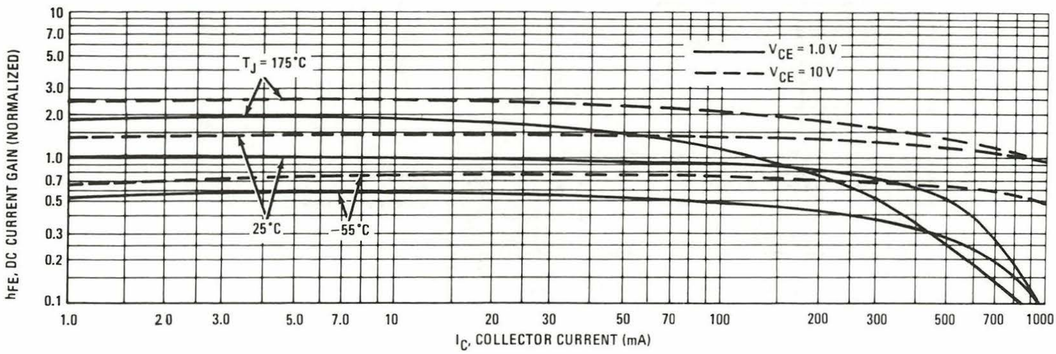


FIGURE 16 — COLLECTOR SATURATION REGION

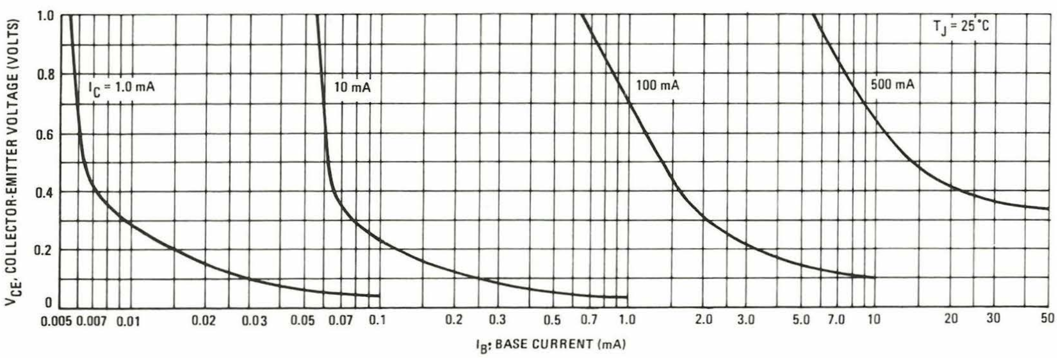


FIGURE 17 — "ON" VOLTAGES

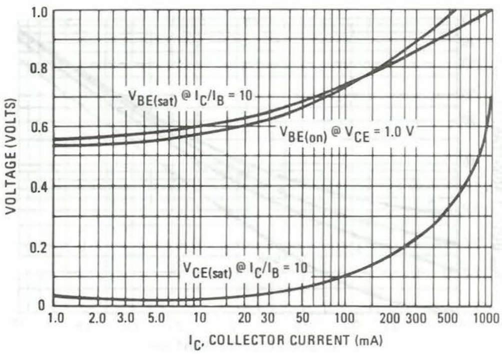
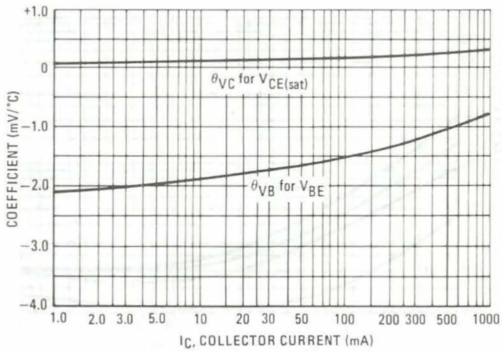


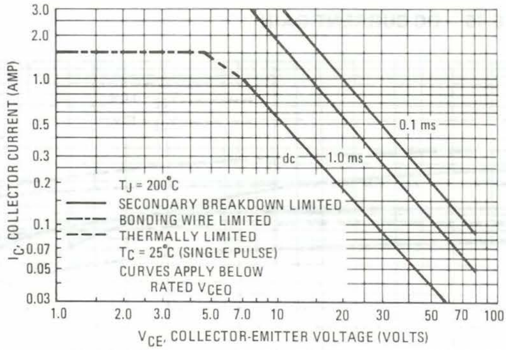
FIGURE 18 — TEMPERATURE COEFFICIENTS



4

RATINGS AND THERMAL DATA

FIGURE 19 — SAFE OPERATING AREA

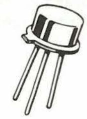


The safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 19 is based upon $T_{J(pk)}$ = 200°C; T_C is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leq$ 200°C. $T_{J(pk)}$ may be calculated from the data in Figure 20. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

2N4406
2N4407

CASE 79, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Base Voltage	V_{CBO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	2.0	Amps
Total Device Dissipation @ T_A = 25°C* Derate above 25°C	P_D	1.25 7.15	Watts mW/°C
Total Device Dissipation @ T_C = 25°C* Derate above 25°C	P_D	8.75 50	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	20	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	140	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$	80	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	80	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)		I_{CBO}	—	25	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	25	nAdc
ON CHARACTERISTICS					
DC Current Gain(1)		h_{FE}			—
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	2N4406		30	—	
	2N4407		80	—	
(I_C = 150 mAdc, V_{CE} = 5.0 Vdc)	2N4406		30	—	
	2N4407		80	—	
(I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	2N4406		30	120	
	2N4407		80	240	
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	2N4406		20	—	
	2N4407		30	—	
(I_C = 1.5 Adc, V_{CE} = 5.0 Vdc)	2N4406, 2N4407		10	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	0.2	
(I_C = 500 mAdc, I_B = 50 mAdc)			—	0.4	
(I_C = 1.0 Adc, I_B = 100 mAdc)			—	0.7	
(I_C = 1.5 Adc, I_B = 150 mAdc)			—	1.5	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	0.9	
(I_C = 1.0 Adc, I_B = 100 mAdc)			0.9	1.3	
(I_C = 1.5 Adc, I_B = 150 mAdc)			—	1.5	
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	150	750	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	—	15	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{eb}	—	160	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc, I_C = 1.0 Adc, I_{B1} = 100 mAdc)	t_d	—	15	ns
Rise Time		t_r	—	60	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 1.0 Adc, I_{B1} = I_{B2} = 100 mAdc)	t_s	—	175	ns
Fall Time		t_f	—	50	ns

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.
*Indicates Data in addition to JEDEC Requirements.

4

STATIC CHARACTERISTICS

FIGURE 1 — DC CURRENT GAIN

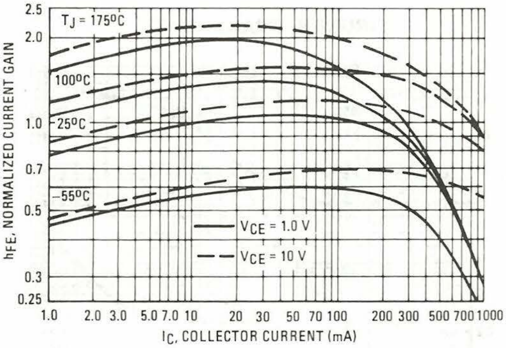


FIGURE 2 — COLLECTOR SATURATION REGION

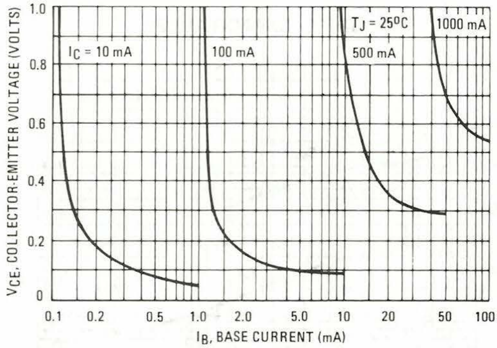


FIGURE 3 — "ON" VOLTAGES

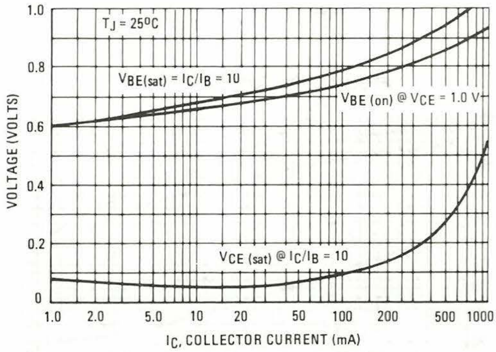


FIGURE 4 — TEMPERATURE COEFFICIENTS

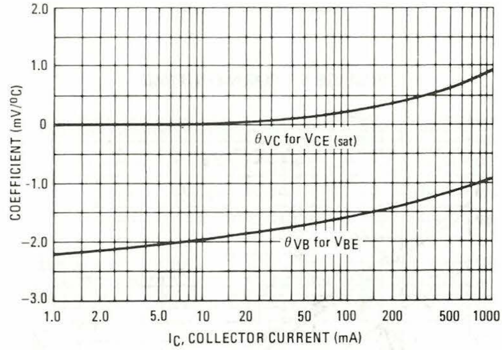
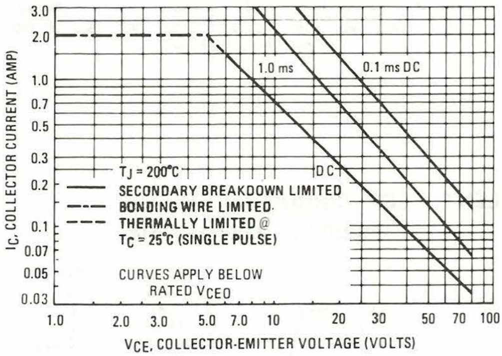


FIGURE 5 — SAFE OPERATING AREA



The safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 5 is based upon $T_{J(pk)}$ = 200°C; T_C is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200$°C. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

TRANSIENT CHARACTERISTICS

——— 25°C – – – 100°C

FIGURE 7 - CAPACITANCES

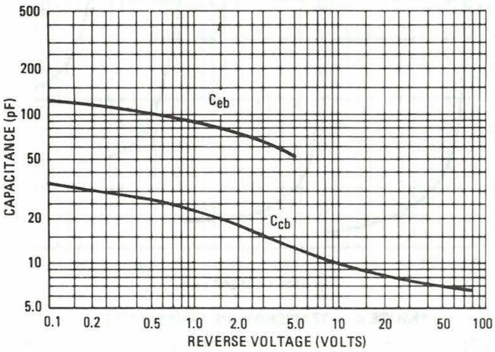


FIGURE 8 - CHARGE DATA

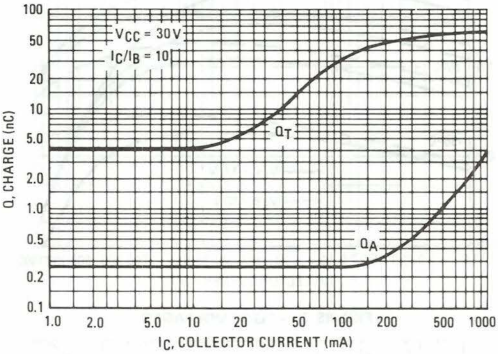


FIGURE 9 - TURN-ON TIME

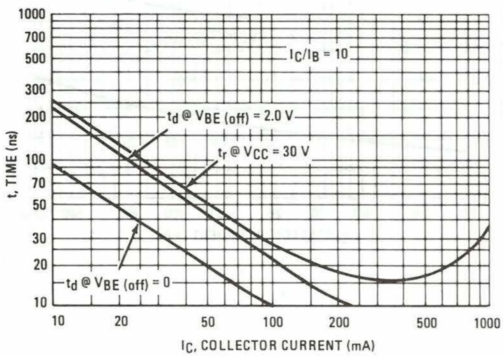
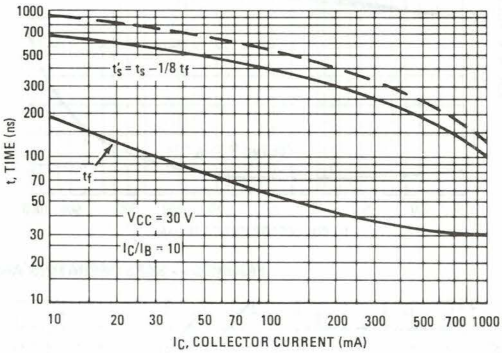


FIGURE 10 - TURN-OFF TIME



SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 11 - TURN-ON TIME

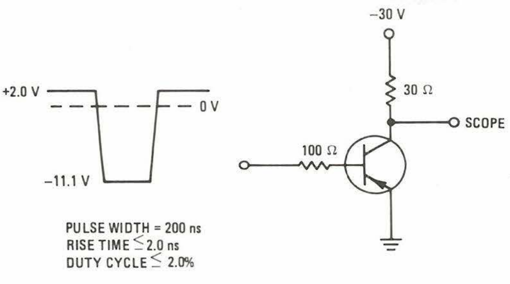
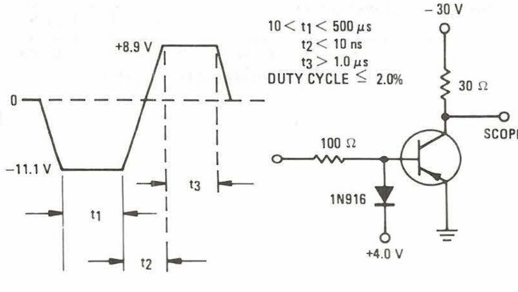


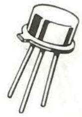
FIGURE 12 - TURN-OFF TIME



2N4453 For Specifications, See 2N869A Data.

2N4890

CASE 79-02, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTOR

PNP SILICON

4

Refer to 2N4033 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.7	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) ($I_C = 100\ \mu Adc$, $I_B = 0$)		$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $R_{BE} = 10$ ohms)		$V_{(BR)CER}$	50	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu Adc$, $I_E = 0$)		$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu Adc$, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 60$ Vdc, $V_{BE(off)} = 1.5$ Vdc)		I_{CEX}	—	—	0.25	μAdc
Base Cutoff Current ($V_{CE} = 60$ Vdc, $V_{BE(off)} = 1.5$ Vdc)		I_{BL}	—	—	0.25	μAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = 150$ mAdc, $V_{CE} = 2.5$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc) *($I_C = 500$ mA, $V_{CE} = 5$ Vdc(1))		h_{FE}	 25 50 15	 130 140 —	 — 250 —	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)		$V_{CE(sat)}$	—	0.12	1.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)		$V_{BE(sat)}$	—	0.82	1.7	Vdc
Base-Emitter On Voltage ($I_C = 150$ mAdc, $V_{CE} = 2.5$ Vdc)		$V_{BE(on)}$	—	0.74	1.7	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)		f_T	100	280	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 140 kHz)		C_{obo}	—	9.0	15	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 140 kHz)		C_{ibo}	—	60	80	pF
SWITCHING CHARACTERISTICS						
Delay Time	($V_{CC} = 30$ Vdc, $V_{BE(off)} = 0.8$ Vdc, $I_C = 150$ mAdc, $I_{B1} = 15$ mAdc)	t_d	—	15	50	ns
Rise Time		t_r	20	20	50	ns
Storage Time	($V_{CC} = 30$ Vdc, $I_C = 150$ mAdc, $I_{B1} = I_{B2} = 15$ mAdc)	t_s	—	110	200	ns
Fall Time		t_f	—	20	70	ns

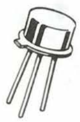
(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.

*Indicates Data in Addition to JEDEC Requirements.

4

2N4924
2N4925

CASE 79-02, STYLE 1
TO-39 (TO-205AD)



AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N3498 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N4924	2N4925	Unit
Collector-Emitter Voltage	V_{CEO}	100	150	Vdc
Collector-Base Voltage	V_{CBO}	100	150	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 10$ mAdc, $I_B = 0$)	 2N4924 2N4925	$V_{(BR)CEO}$	 100 150	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	 2N4924 2N4925	$V_{(BR)CBO}$	 100 150	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$) ($V_{CB} = 75$ Vdc, $I_E = 0$)		I_{CBO}	 — —	 0.1 0.1	μAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)		h_{FE}	 25 35 40	 — — 200	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		$V_{CE(sat)}$	 — —	 0.25 0.4	Vdc
Base-Emitter On Voltage ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc)		$V_{BE(on)}$	—	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (2) ($I_C = 20$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)		f_T	100	500	MHz
Collector-Base Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 140 kHz)		C_{cb}	—	10	pF
Emitter-Base Capacitance ($V_{EB} = 1.0$ Vdc, $I_C = 0$, f = 140 kHz)		C_{eb}	—	80	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \bullet f_{test}$.

2N4926
2N4927

CASE 79, STYLE 1
TO-39 (TO-205AD)

AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N4926	2N4927	Unit
Collector-Emitter Voltage	V_{CEO}	200	250	Vdc
Collector-Base Voltage	V_{CBO}	200	250	Vdc
Emitter-Base Voltage	V_{EBO}	7.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 10$ mAdc, $I_B = 0$)	 2N4926 2N4927	$V_{(BR)CEO}$	 200 250	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_C = 0$)	 2N4926 2N4927	$V_{(BR)CBO}$	 200 250	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)		$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 100$ Vdc, $I_E = 0$) ($V_{CB} = 100$ Vdc, $I_E = 0$, $T_A = 100°C$) ($V_{CB} = 150$ Vdc, $I_E = 0$) ($V_{CB} = 150$ Vdc, $I_E = 0$, $T_A = 100°C$)	 2N4926 2N4927 	I_{CBO}	 — — — —	 0.1 10 0.1 10	μAdc
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS (1)					
DC Current Gain ($I_C = 3.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 20$ Vdc)		h_{FE}	10 15 20 20	— — 200 —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc)		$V_{CE(sat)}$	— —	1.0 2.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 3.0$ mAdc)		$V_{BE(sat)}$	— —	1.2 1.5	Vdc
Base-Emitter On Voltage ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)		$V_{BE(on)}$	—	1.5	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 20 MHz)		f_T	30	300	MHz
Collector-Base Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 140 kHz)		C_{cb}	—	6.0	pF
Input Impedance ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)		h_{ie}	75	2000	ohm
Voltage Feedback Ratio ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)		h_{re}	0.1	2.0	$X\ 10^{-4}$
Small-Signal Current Gain ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)		h_{fe}	25	250	—
Output Admittance ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)		h_{oe}	—	50	μmhos
Real Part of Input Impedance ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 5.0 MHz)		$Re(h_{ie})$	4.0	200	ohms

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

4

2N4928 thru 2N4931

2N4930 and 2N4931 JAN, JTX & JTXV AVAILABLE
CASE 79, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to 2N3494 for graphs for 2N4928.*

MAXIMUM RATINGS

Rating	Symbol	2N4928	2N4929	2N4930	2N4931	Unit
Collector-Emitter Voltage	V_{CEO}	100	150	200	250	Vdc
Collector-Base Voltage	V_{CBO}	100	150	200	250	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	4.0	4.0	4.0	Vdc
Collector Current — Continuous	I_C	100	500	500	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.6 3.4	1.0 5.71	1.0 5.71	1.0 5.71	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.0 17.2	5.0 28.6	5.0 28.6	5.0 28.6	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−65 to +200			°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1)		$V_{(BR)CEO}$			Vdc
(I_C = 10 mAdc, I_B = 0)	2N4928		100	—	
	2N4929		150	—	
	2N4930		200	—	
	2N4931		250	—	
Collector-Base Breakdown Voltage		$V_{(BR)CBO}$			Vdc
(I_E = 0, I_C = 100 μAdc)	2N4928		100	—	
	2N4929		150	—	
	2N4930		200	—	
	2N4931		250	—	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 50 Vdc, I_E = 0)	2N4928		—	0.5	
(V_{CB} = 75 Vdc, I_E = 0)	2N4929		—	0.5	
(V_{CB} = 150 Vdc, I_E = 0)	2N4930, 2N4931		—	1.0	
Emitter Cutoff Current		I_{EBO}			μAdc
(V_{BE} = 3.0 Vdc, I_C = 0)	2N4928, 2N4929		—	0.5	
(V_{BE} = 3.0 Vdc, I_C = 0)	2N4930, 2N4931		—	1.0	
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	All Types		20	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)(1)	2N4928, 2N4929		25	200	
	2N4930, 2N4931		20	200	
(I_C = 50 mAdc, V_{CE} = 10 Vdc)(1)	2N4928, 2N4929		20	—	
(I_C = 30 mAdc, V_{CE} = 10 Vdc)(1)	2N4930, 2N4931		20	—	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	2N4928, 2N4929		—	0.5	
	2N4930, 2N4931		—	5.0	
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 10 Vdc)		$V_{BE(on)}$	—	1.0	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product		f_T			MHz
(I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N4928, 2N4929		100	1,000	
(I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	2N4930, 2N4931		20	200	
Collector-Base Capacitance		C_{cb}			pF
(V_{CB} = 20 Vdc, I_E = 0, f = 140 kHz)	2N4928		—	6.0	
(V_{CB} = 20 Vdc, I_E = 0, f = 140 kHz)	2N4929		—	10	
(V_{CB} = 20 Vdc, I_E = 0, f = 140 kHz)	2N4930, 2N4931		—	20	
Emitter-Base Capacitance		C_{eb}			pF
(V_{BE} = 2.0 Vdc, I_C = 0, f = 140 kHz)	2N4928		—	40	
(V_{BE} = 1.0 Vdc, I_C = 0, f = 140 kHz)	2N4929		—	80	
(V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	2N4930, 2N4931		—	400	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Refer to 2N3634 for graphs for 2N4929.
Refer to 2N3743 for graphs for 2N4930 and 2N4931.

4

2N5022
2N5023

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to 2N3467 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N5022	2N5023	Unit
Collector-Emitter Voltage	V_{CEO}	50	30	V
Collector-Emitter Voltage	V_{CES}	50	30	V
Collector-Base Voltage	V_{CBO}	50	30	V
Emitter-Base Voltage	V_{EBO}	5		V
Collector Current — Continuous (Pulse Width = 300 μs, DC = 1%)	I_C	1.0*		A
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.72		Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	4.0 22.8		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C
Maximum Lead Temperature (Soldering, 60 sec max)	T_L	+300		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	43.8	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W

*Indicates Data in Addition to JEDEC Requirements.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc)	2N5022 2N5023	$V_{(BR)CES}$	50 30	— —	V
Collector-Emitter Sustaining Voltage (I_C = 10 mAdc)	2N5022 2N5023	$V_{(BR)CEO(sus)}$*	50 30	— —	V
Collector-Base Breakdown Voltage (I_C = 100 μAdc)	2N5022 2N5023	$V_{(BR)CBO}$	50 30	— —	V
Emitter-Base Breakdown Voltage (I_E = 100 μAdc)	All	$V_{(BR)EBO}$	5.0	—	V
Collector Cutoff Current (V_{CE} = 30 Vdc) (V_{CE} = 20 Vdc) (T_A = 100°Cdc)	2N5022 2N5023	I_{CES}	— —	100 15	nA μA
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 100 mA, V_{CE} = 1.0 Vdc)	2N5022 2N5023	h_{FE}	15 30	— —	—
(I_C = 500 mA, V_{CE} = 1.0 Vdc)	2N5022 2N5023		25 40	100 100	
(I_C = 1.0 A, V_{CE} = 5.0 Vdc)	2N5022 2N5023		25 40	— —	
(I_C = 500 ma, V_{CE} = 1.0 V, T_A = −55°C)	2N5022 2N5023		10 20	— —	
Collector-Emitter Saturation Voltage(1) (I_C = 100 mAdc, I_B = 10 mAdc)	2N5022 2N5023	$V_{CE(sat)}$	— —	0.20 0.17	V
(I_C = 500 mAdc, I_B = 50 mAdc)	2N5022 2N5023		— —	0.40 0.35	V
(I_C = 1.0 Adc, I_B = 100 mAdc)	2N5022 2N5023		— —	0.80 0.70	V

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			
(I_C = 100 mAdc, I_B = 10 mAdc)			—	1.0	V
(I_C = 500 mAdc, I_B = 50 mAdc)			0.8	1.4	V
(I_C = 1.0 Adc, I_B = 100 mAdc)			—	1.75	V
SMALL-SIGNAL CHARACTERISTICS					
Collector-Base Capacitance (V_{BE} = 0.5 V, f = 100 kHz)		C_{cb}	—	25	pF
Emitter-Base Capacitance (V_{BE} = 0.5 V, f = 100 kHz)		C_{eb}	—	100	pF
Small-Signal Current Gain		h_{fe}			—
(I_C = 50 mA, V_{CE} = 10 V, f = 100 MHz)	2N5022		1.7	—	
	2N5023		2.0	—	
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CE} = −30 V, I_C ≈ 500 mA, I_B ≈ 50 mA)		t_{on}	—	40	ns
Turn-Off Time (V_{CE} = 30 V, I_C ≈ 500 mA, I_{B1} = I_{B2} ≈ 50 mA)		t_{off}	—	90	ns

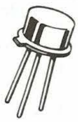
(1) Pulse Width = 300 μs, Duty Cycle = 1.0%.

4

4

2N5058
2N5059

CASE 79-02, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N3724 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N5058	2N5059	Unit
Collector-Emitter Voltage	V_{CEO}	300	250	Vdc
Collector-Base Voltage	V_{CBO}	300	250	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	6.0	Vdc
Collector Current — Continuous	I_C	150		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 6.67		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 33.3		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	30	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$ (1)	150	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (2) ($I_C = 30$ mAdc, $I_B = 0$)	 2N5058 2N5059	$V_{(BR)CEO}$	 300 250	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	 2N5058 2N5059	$V_{(BR)CBO}$	 300 250	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	 2N5058 2N5059	$V_{(BR)EBO}$	 7.0 6.0	 — —	Vdc
Collector Cutoff Current ($V_{CB} = 100$ Vdc, $I_E = 0$) ($V_{CB} = 100$ Vdc, $I_E = 0$, $T_A = +125°C$)		I_{CBO}	— —	0.05 20	μAdc
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$)		I_{EBO}	—	10	nAdc
ON CHARACTERISTICS (2)					
DC Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 25$ Vdc)	 2N5058 2N5059	h_{FE}	 10 10	 — —	—
($I_C = 30$ mAdc, $V_{CE} = 25$ Vdc)	2N5058 2N5059		35 30	150 150	
($I_C = 30$ mAdc, $V_{CE} = 25$ Vdc, $T_A = -55°C$)	2N5058		10	—	
($I_C = 100$ mAdc, $V_{CE} = 25$ Vdc)	2N5058 2N5059		35 30	— —	
Collector-Emitter Saturation Voltage ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc)		$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc)		$V_{BE(sat)}$	—	0.85	Vdc
Base-Emitter On Voltage ($I_C = 30$ mAdc, $V_{CE} = 25$ Vdc)		$V_{BE(on)}$	—	0.82	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (3) ($I_C = 10$ mAdc, $V_{CE} = 25$ Vdc, f = 20 MHz)		f_T	30	160	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{cb}	—	10	pF
Emitter-Base Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)		C_{eb}	—	75	pF

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(3) f_T is defined as the frequency at which the $|h_{fe}|$ extrapolates to unity.

2N5229
2N5230
2N5231

CASE 26-03, STYLE 1
TO-46 (TO-206AB)

LOW POWER CHOPPER TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N5229	2N5230	2N5231	Unit
Emitter-Collector Voltage	V_{ECO}	10	20	30	Vdc
Collector-Base Voltage	V_{CBO}	15	30	50	Vdc
Emitter-Base Voltage	V_{EBO}	15	30	50	Vdc
Collector Current — Continuous	I_C	50			mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 2.86			Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.0 12			Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200			°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Emitter-Collector Breakdown Voltage (I_E = 10 μAdc, I_B = 0)	2N5229 2N5230 2N5231	$V_{(BR)ECO}$	10 20 30	— — —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N5229 2N5230 2N5231	$V_{(BR)CBO}$	15 30 50	— — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	2N5229 2N5230 2N5231	$V_{(BR)EBO}$	15 30 50	— — —	Vdc
Collector Cutoff Current (V_{CB} = 12 Vdc, I_E = 0) (V_{CB} = 25 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0)	2N5229 2N5230 2N5231	I_{CBO}	— — —	1.0 1.0 1.0	nAdc
Emitter Cutoff Current (V_{EB} = 12 Vdc, I_C = 0) (V_{EB} = 25 Vdc, I_C = 0) (V_{EB} = 40 Vdc, I_C = 0)	2N5229 2N5230 2N5231	I_{EBO}	— — —	1.0 1.0 1.0	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 1.0 Vdc) (I_C = 200 μAdc, V_{CE} = 0.5 Vdc) (Inverted Connection)		h_{FE}	50 15	— —	—
Offset Voltage (I_B = 100 μAdc, I_E = 0)	2N5229, 2N5230, 2N5231	$V_{EC(ofs)}$	— —	0.5 0.8	mVdc
(I_B = 1.0 mAdc, I_E = 0)	2N5229, 2N5230, 2N5231		— —	0.8 1.0	
SMALL-SIGNAL CHARACTERISTICS					
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)		C_{cb}	—	5.0	pF
Emitter-Base Capacitance (V_{EB} = 10 Vdc, I_C = 0, f = 140 kHz)		C_{eb}	—	4.0	pF
Small Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 4.0 MHz)		h_{fe}	2.0	—	—

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
"ON" Series Resistance (I_B = 1.0 mAdc, I_E = 0, I_e = 100 μA RMS, f = 1.0 kHz)	2N5229	$r_{ec(on)}$	1.0	6.0	Ohms
	2N5230		2.0	8.0	
	2N5231		2.0	10	

TYPICAL CHARACTERISTICS

FIGURE 1 — EMITTER-COLLECTOR VOLTAGE versus BASE CURRENT

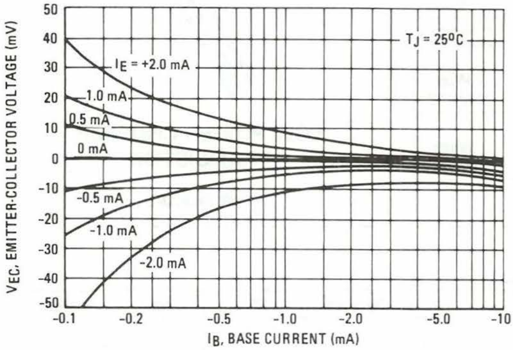


FIGURE 2 — EMITTER-COLLECTOR VOLTAGE versus JUNCTION TEMPERATURE

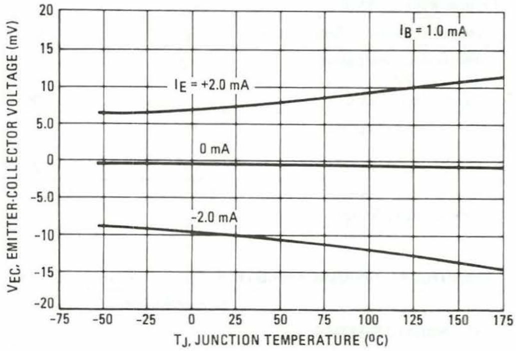


FIGURE 3 — EMITTER-COLLECTOR "ON" RESISTANCE versus BASE CURRENT

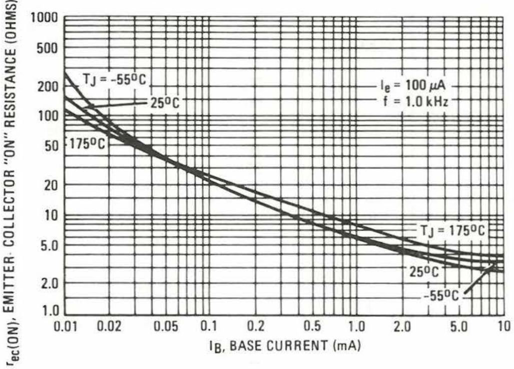


FIGURE 4 — EMITTER-COLLECTOR "ON" RESISTANCE TEMPERATURE COEFFICIENT versus BASE CURRENT

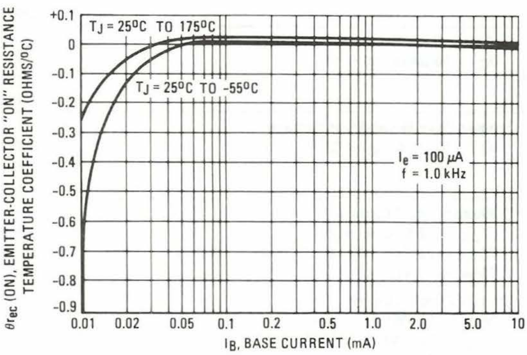


FIGURE 5 — CURRENT GAIN versus COLLECTOR CURRENT

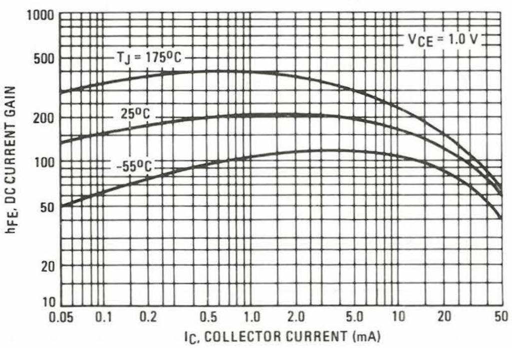


FIGURE 6 — CURRENT GAIN (Inverted Connection) versus EMITTER CURRENT

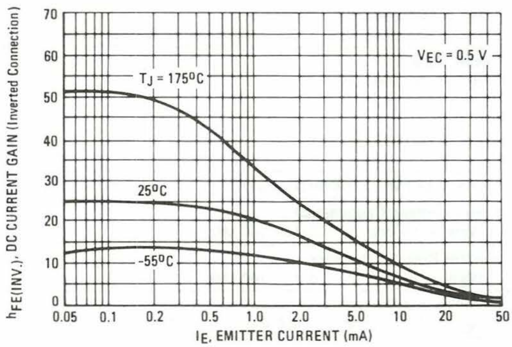


FIGURE 7 – COLLECTOR CUTOFF CURRENT versus JUNCTION TEMPERATURE

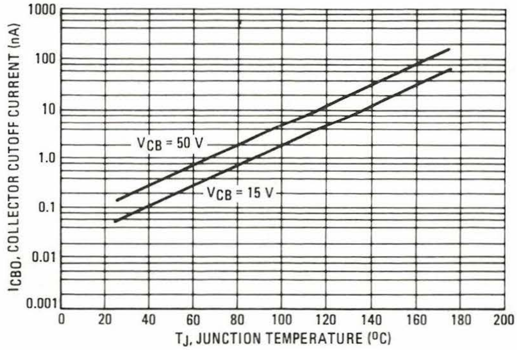


FIGURE 8 – EMITTER CUTOFF CURRENT versus JUNCTION TEMPERATURE

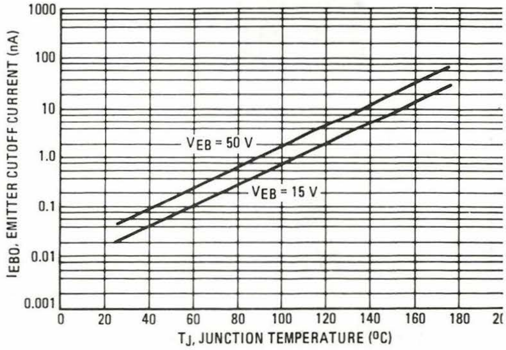


FIGURE 9 – COLLECTOR-EMITTER SATURATION VOLTAGE versus COLLECTOR CURRENT

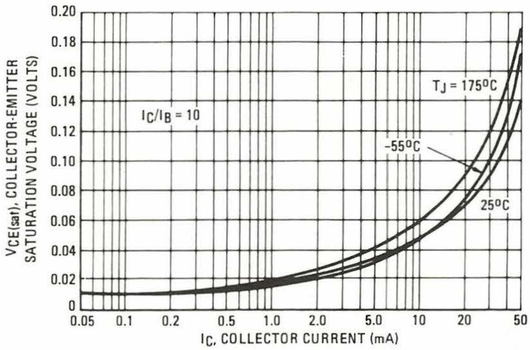
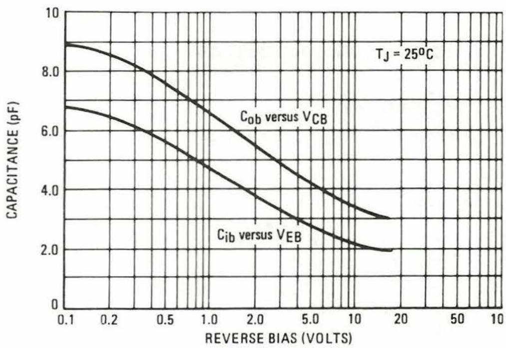


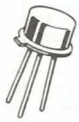
FIGURE 10 – JUNCTION CAPACITANCE versus REVERSE BIAS VOLTAGE



4

2N5320
2N5321

CASE 79, STYLE 1
TO-39 (TO-205AD)



SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N5320	2N5321	Unit
Collector-Emitter Voltage	V_{CEO}	75	50	Vdc
Collector-Base Voltage	V_{CBO}	100	75	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	5.0	Vdc
Base Current	I_B	1.0		Adc
Collector Current — Continuous	I_C	2.0		Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	10 0.057		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

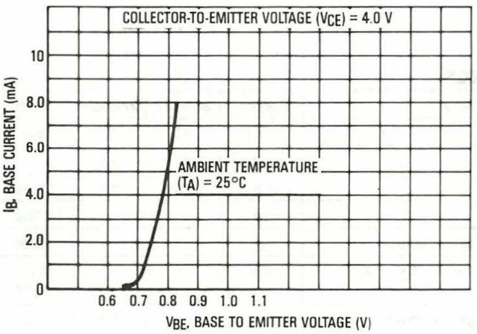
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	17.5	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

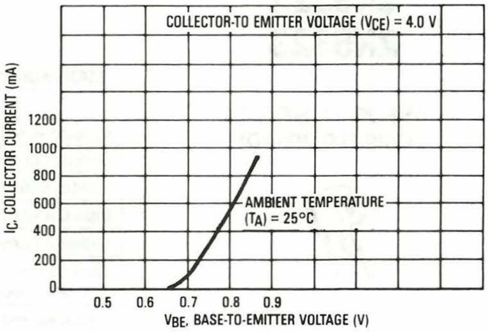
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100$ mAdc, $I_B = 0$)	 2N5320 2N5321	$V_{(BR)CEO}$	 75 50	 — —	Vdc
Collector Cutoff Current ($V_{CE} = 100$ Vdc, $V_{BE} = 1.5$ Vdc) ($V_{CE} = 70$ Vdc, $V_{BE} = 1.5$ Vdc, $T_C = 150°C$) ($V_{CE} = 75$ Vdc, $V_{BE} = 1.5$ Vdc) ($V_{CE} = 45$ Vdc, $V_{BE} = 1.5$ Vdc, $T_C = 150°C$)	 2N5320 2N5321 	I_{CEX}	 — — — —	 0.1 5.0 0.1 5.0	mAdc
Emitter Cutoff Current ($V_{BE} = 7.0$ Vdc, $I_C = 0$) ($V_{BE} = 5.0$ Vdc, $I_C = 0$)	 2N5320 2N5321	I_{EBO}	 —	 0.1 0.1	mAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 500$ mAdc, $V_{CE} = 4.0$ Vdc) ($I_C = 1.0$ Adc, $V_{CE} = 2.0$ Vdc)	 2N5320 2N5321 2N5320	h_{FE}	 30 40 10	 130 250 —	—
Collector-Emitter Saturation Voltage ($I_C = 500$ mAdc, $I_B = 50$ mAdc)	 2N5320 2N5321	$V_{CE(sat)}$	 — —	 0.5 0.8	Vdc
Base-Emitter On Voltage ($I_C = 500$ mAdc, $V_{CE} = 4.0$ Vdc)	 2N5320 2N5321	$V_{BE(on)}$	 —	 1.1 1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Small-Signal Current Gain ($I_C = 50$ mAdc, $V_{CE} = 4.0$ Vdc, f = 10 MHz)		h_{fe}	5	—	—
SWITCHING CHARACTERISTICS					
Turn-On Time ($V_{CC} = 30$ Vdc, $I_C = 500$ mAdc, $I_{B1} = 50$ mAdc)		t_{on}	—	80	ns
Turn-Off Time ($V_{CC} = 30$ Vdc, $I_C = 500$ mAdc, $I_{B1} = I_{B2} = 50$ mAdc)		t_{off}	—	800	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

TYPICAL INPUT CHARACTERISTICS

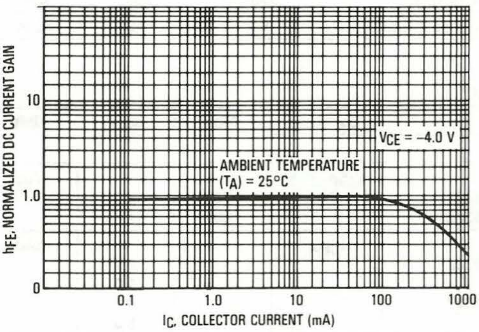


TYPICAL TRANSFER CHARACTERISTICS

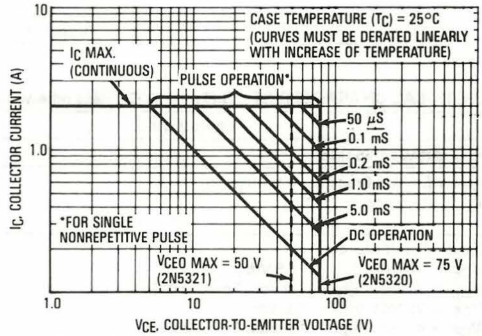


4

CURRENT GAIN CHARACTERISTICS versus COLLECTOR-EMITTER VOLTAGE

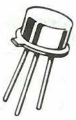


MAXIMUM SAFE OPERATING AREAS (SOA)



2N5322
2N5323

CASE 79-02, STYLE 1
TO-39 (TO-205AD)



SWITCHING TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N5322	2N5323	Unit
Collector-Emitter Voltage	V_{CEO}	75	50	Vdc
Collector-Base Voltage	V_{CBO}	100	75	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	5.0	Vdc
Base Current	I_B	1.0		Adc
Collector Current — Continuous	I_C	2.0		Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	10 0.057		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

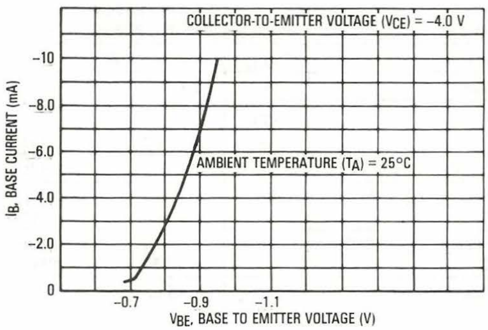
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	17.5	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

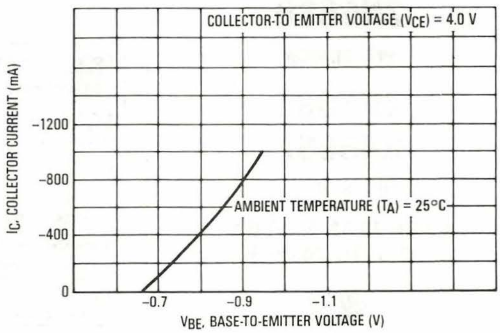
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 100$ mAdc, $I_B = 0$)	 2N5322 2N5323	$V_{(BR)CEO}$	 75 50	 — —	Vdc
Collector Cutoff Current ($V_{CE} = 100$ Vdc, $V_{BE} = 1.5$ Vdc) ($V_{CE} = 70$ Vdc, $V_{BE} = 1.5$ Vdc, $T_C = 150°C$) ($V_{CE} = 75$ Vdc, $V_{BE} = 1.5$ Vdc) ($V_{CE} = 45$ Vdc, $V_{BE} = 1.5$ Vdc, $T_C = 150°C$)	 2N5322 2N5323 	I_{CEX}	 — — — —	 0.1 5.0 0.1 5.0	mAdc
Emitter Cutoff Current ($V_{BE} = 7.0$ Vdc, $I_C = 0$) ($V_{BE} = 5.0$ Vdc, $I_C = 0$)	 2N5322 2N5323	I_{EBO}	 — —	 0.1 0.1	mAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 500$ mAdc, $V_{CE} = 4.0$ Vdc) ($I_C = 1.0$ Adc, $V_{CE} = 2.0$ Vdc)	 2N5322 2N5323 2N5322	h_{FE}	 30 40 10	 130 250 —	—
Collector-Emitter Saturation Voltage ($I_C = 500$ mAdc, $I_B = 50$ mAdc)	 2N5322 2N5323	$V_{CE(sat)}$	 —	 0.7 1.2	Vdc
Base-Emitter On Voltage ($I_C = 500$ mAdc, $V_{CE} = 4.0$ Vdc)	 2N5322 2N5323	$V_{BE(on)}$	 —	 1.1 1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Small-Signal Current Gain ($I_C = 50$ mAdc, $V_{CE} = 4.0$ Vdc, f = 10 MHz)		h_{fe}	5	—	—
SWITCHING CHARACTERISTICS					
Turn-On Time ($V_{CC} = 30$ Vdc, $I_C = 500$ mAdc, $I_{B1} = 50$ mAdc)		t_{on}	—	100	ns
Turn-Off Time ($V_{CC} = 30$ Vdc, $I_C = 500$ mAdc, $I_{B1} = I_{B2} = 50$ mAdc)		t_{off}	—	1000	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

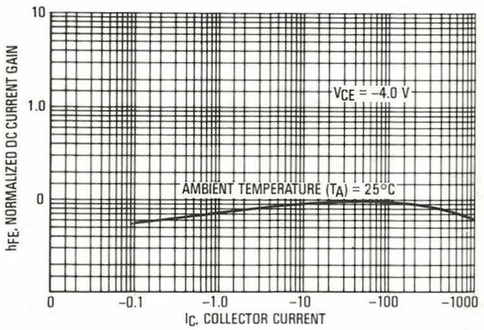
TYPICAL INPUT CHARACTERISTICS



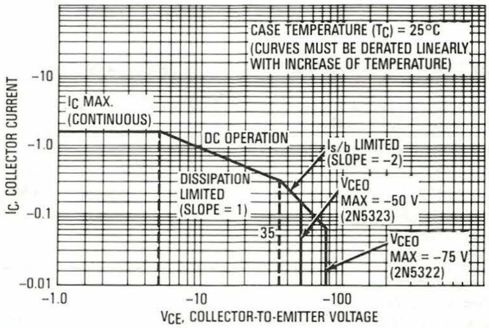
TYPICAL TRANSFER CHARACTERISTICS



CURRENT GAIN CHARACTERISTICS versus COLLECTOR-EMITTER VOLTAGE



MAXIMUM SAFE OPERATING AREAS (SOA)



2N5415, 2N5416

For Specifications, See 2N3439 Data.

2N5581

For Specifications, See 2N2218 Data.

2N5679
2N5680

PNP SILICON

2N5681
2N5682

NPN SILICON

CASE 79-02, STYLE 1
TO-5 (TO-205AA)

GENERAL PURPOSE TRANSISTOR

MAXIMUM RATINGS

Rating	Symbol	2N5679 2N5681	2N5680 2N5682	Unit
Collector-Emitter Voltage	V_{CEO}	100	120	Vdc
Collector-Base Voltage	V_{CBO}	100	120	Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Base Current	I_B	0.5		Adc
Collector Current — Continuous	I_C	1.0		Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.7		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	10 57		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

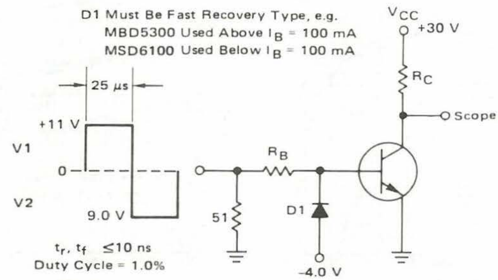
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	17.5	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 10 mAdc, I_B = 0)	 2N5679, 2N5681 2N5680, 2N5682	$V_{CEO(sus)}$	 100 120	 — —	Vdc
Collector Cutoff Current (V_{CE} = 70 Vdc, I_B = 0) (V_{CE} = 80 Vdc, I_B = 0)		I_{CEO}	 — —	 10 10	μAdc
Collector Cutoff Current (V_{CE} = 100 Vdc, V_{EB} = 1.5 Vdc) (V_{CE} = 120 Vdc, V_{EB} = 1.5 Vdc) (V_{CE} = 100 Vdc, V_{EB} = 1.5 Vdc, T_C = 150°C) (V_{CE} = 120 Vdc, V_{EB} = 1.5 Vdc, T_C = 150°C)	 2N5679, 2N5681 2N5680, 2N5682 2N5679, 2N5681 2N5680, 2N5682	I_{CEX}	 — — — —	 1.0 1.0 1.0 1.0	 μAdc mAdc
Collector Cutoff Current (V_{CB} = 100 Vdc, I_E = 0) (V_{CB} = 120 Vdc, I_E = 0)	 2N5679, 2N5681 2N5680, 2N5682	I_{CBO}	 — —	 1.0 1.0	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	—	1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 250 mAdc, V_{CE} = 2.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)		h_{FE}	 40 5.0	 150 —	—
Collector-Emitter Saturation Voltage (I_C = 250 mAdc, I_B = 25 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1.0 Adc, I_B = 200 mAdc)		$V_{CE(sat)}$	 — — —	 0.6 1.0 2.0	Vdc
Base-Emitter Saturation Voltage (I_C = 250 mAdc, V_{CE} = 2.0 Vdc)		$V_{BE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)		f_T	30	—	—
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	50	pF
Small-Signal Current Gain (I_C = 0.2 Adc, V_{CE} = 1.5 Vdc, f = 1.0 kHz)		h_{fe}	40	—	—

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT



R_B and R_C Varied to Obtain Desired Current Levels

For t_d and t_r, D1 is disconnected and V2 = 0
For PNP test circuit, reverse diode and voltage polarities.

PNP
2N5679, 2N5680

NPN
2N5681, 2N5682

FIGURE 2 — TURN-ON TIME

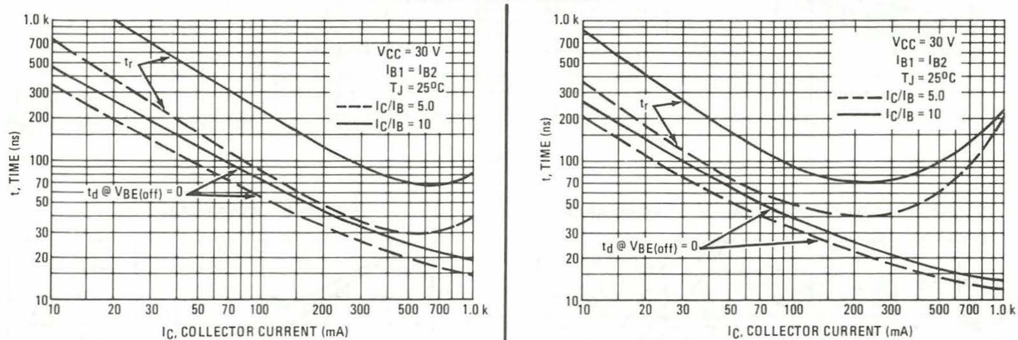


FIGURE 3 — TURN-OFF TIME

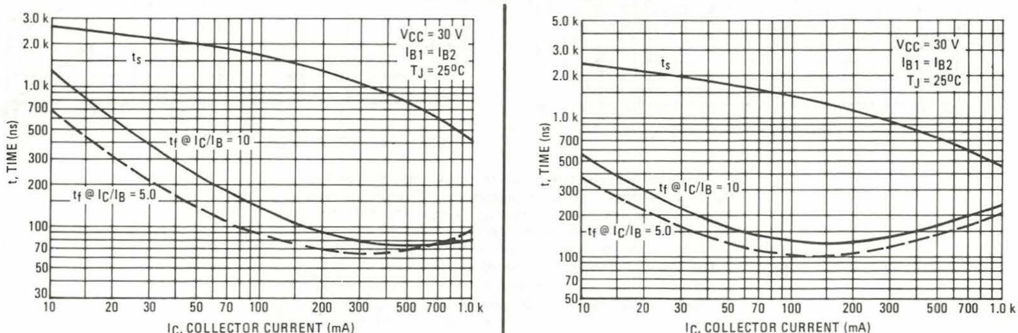


FIGURE 4 – CURRENT-GAIN – BANDWIDTH PRODUCT

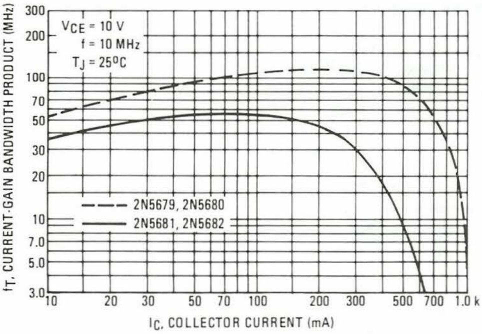


FIGURE 5 – CAPACITANCE

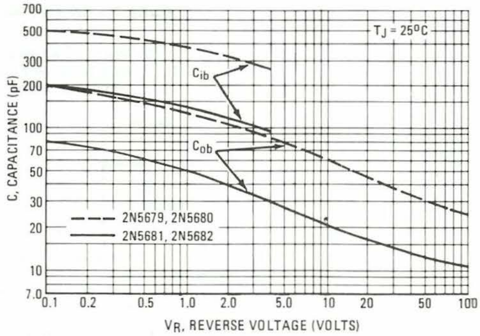


FIGURE 6 – THERMAL RESISTANCE

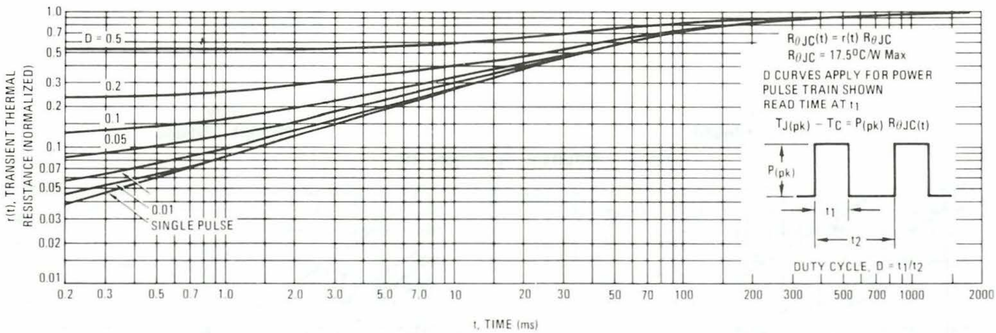


FIGURE 7 – ACTIVE-REGION SAFE OPERATING AREA

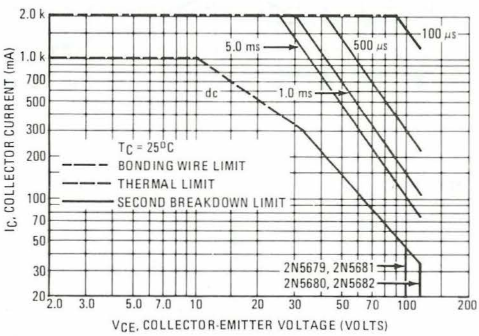
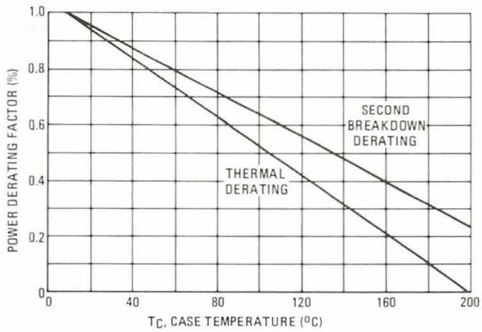


FIGURE 8 – POWER DERATING



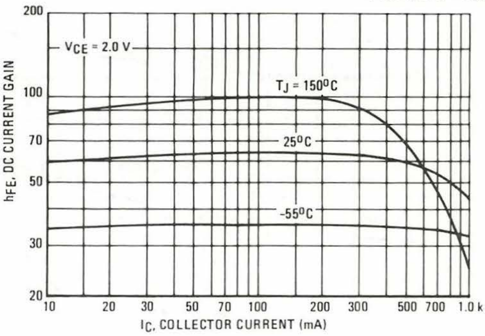
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 7 is based on T_C = 25°C; $T_{J(pk)}$ is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 7 may be found at any case temperature by using the appropriate curve on Figure 8.

PNP
2N5679, 2N5680

NPN
2N5681, 2N5682

FIGURE 9 — DC CURRENT GAIN



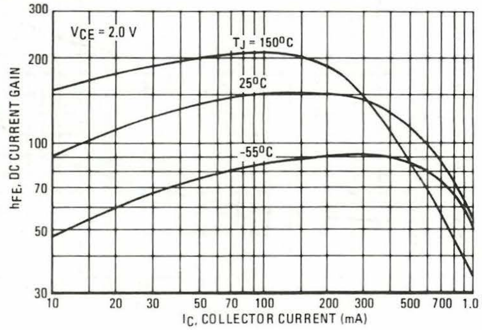
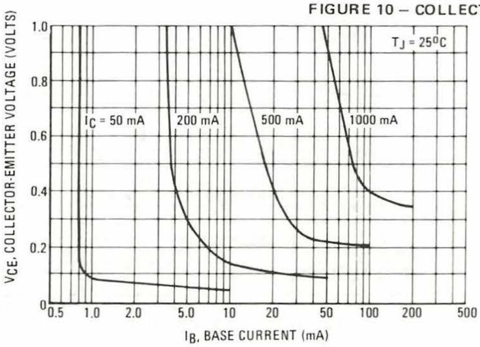


FIGURE 10 — COLLECTOR SATURATION REGION



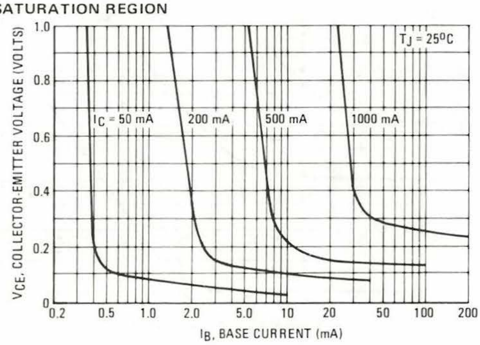
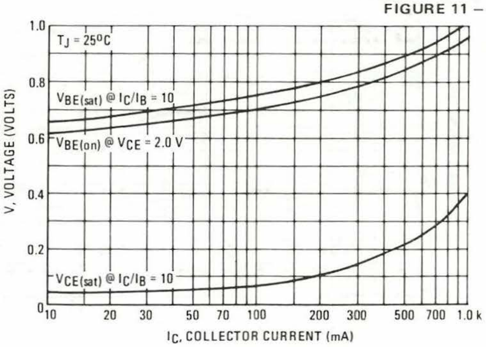
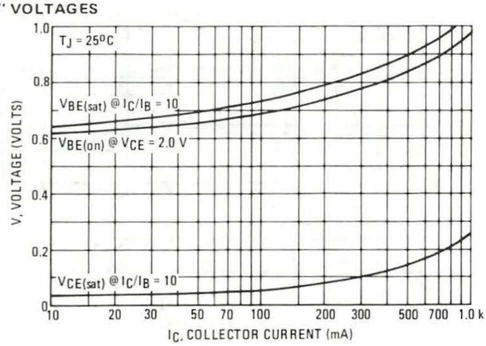


FIGURE 11 — "ON" VOLTAGES





PNP
2N5679, 2N5680

NPN
2N5681, 2N5682

FIGURE 12 – TEMPERATURE COEFFICIENTS

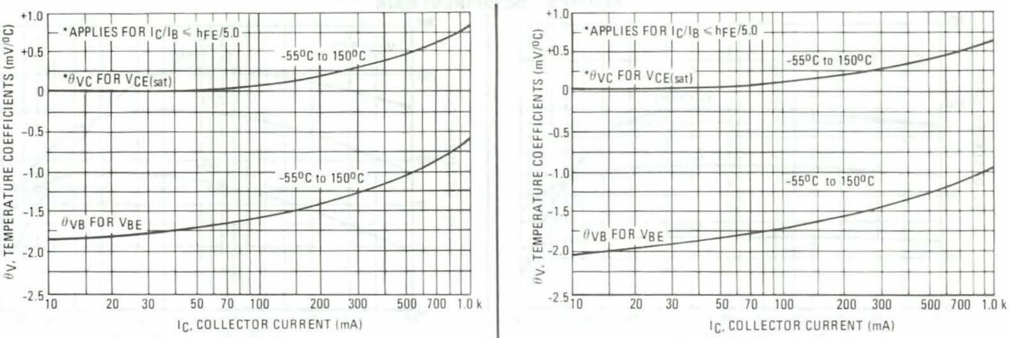


FIGURE 13 – COLLECTOR CUTOFF REGION

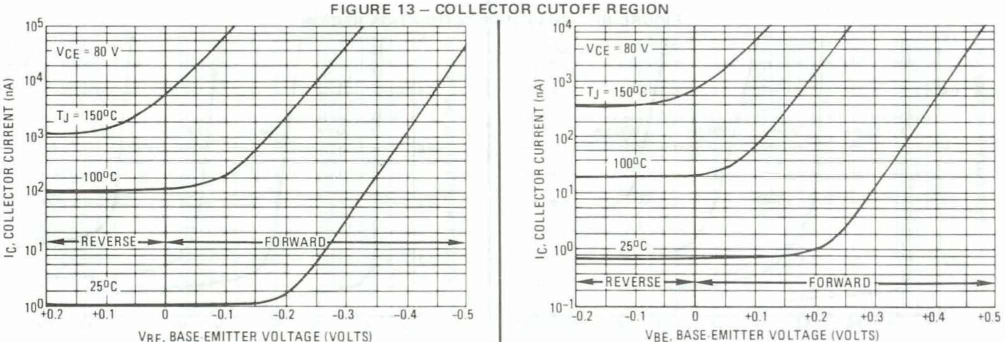
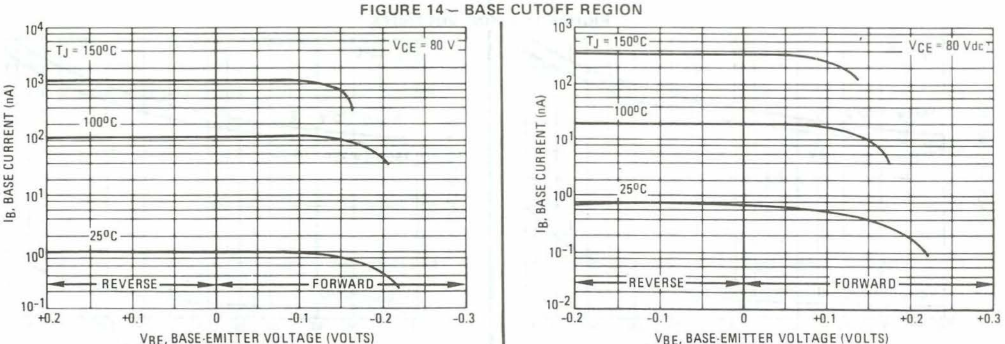


FIGURE 14 – BASE CUTOFF REGION



2N5859

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

SWITCHING TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	2.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 6.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

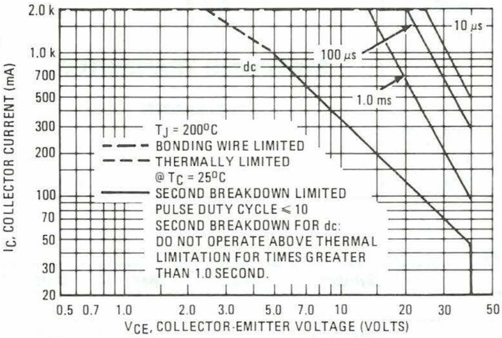
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	80	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CE} = 50 Vdc, $V_{BE(off)}$ = 2.0 Vdc) (V_{CE} = 50 Vdc, $V_{BE(off)}$ = 2.0 Vdc, T_A = 75°C)	I_{CEX}	— —	0.2 5.0	μAdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = 75°C)	I_{CBO}	— —	0.25 5.0	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 500 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc, T_A = −55°C)	h_{FE}	30 15 10	120 100 —	—
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1.0 Adc, I_B = 100 mAdc)	$V_{CE(sat)}$	— —	0.4 0.7	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1.0 Adc, I_B = 100 mAdc)	$V_{BE(sat)}$	0.8 0.9	1.0 1.25	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	250	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	—	7.0	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{eb}	—	60	pF
SWITCHING CHARACTERISTICS				
Delay Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc, I_C = 1.0 Adc, I_{B1} = 100 mAdc) (Figures 8 and 10)	t_d	—	6.0	ns
Rise Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc, I_C = 1.0 Adc, I_{B1} = 100 mAdc) (Figures 8 and 10)	t_r	—	30	ns
Storage Time (V_{CC} = 30 Vdc, I_C = 1.0 Adc, I_{B1} = I_{B2} = 100 mAdc) (Figures 9 and 11)	t_s	—	35	ns
Fall Time (V_{CC} = 30 Vdc, I_C = 1.0 Adc, I_{B1} = I_{B2} = 100 mAdc) (Figures 9 and 11)	t_f	—	35	ns

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Turn-On Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc, I_C = 1.0 Adc, I_{B1} = 100 mAdc) (Figures 8 and 10)	t_{on}	—	35	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 1.0 Adc, I_{B1} = I_{B2} = 100 mAdc) (Figures 9 and 11)	t_{off}	—	60	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on $T_{J(pk)}$ = 200°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq$ 200°C. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

TYPICAL DC CHARACTERISTICS

FIGURE 2 — DC CURRENT GAIN

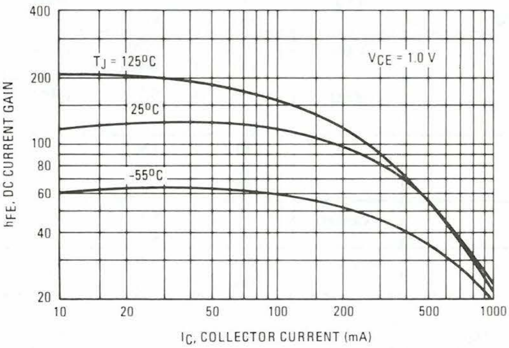


FIGURE 3 — "ON" VOLTAGES

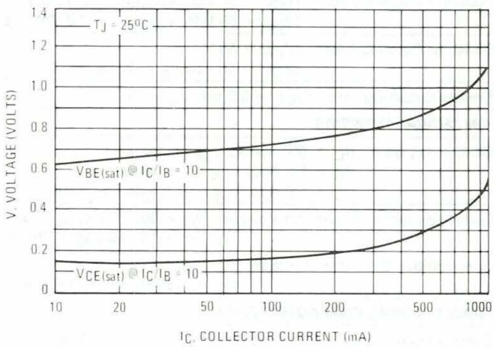


FIGURE 4 — COLLECTOR SATURATION REGION

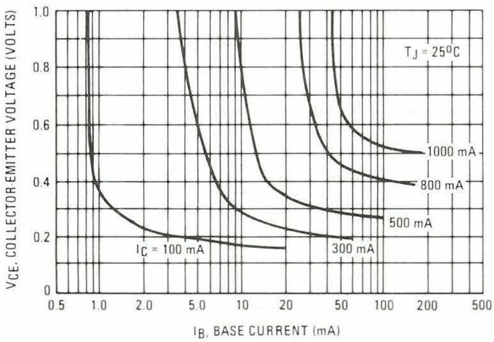
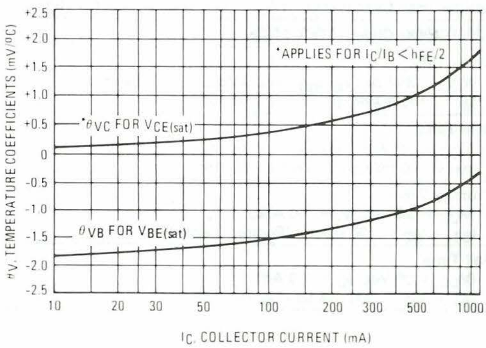


FIGURE 5 — TEMPERATURE COEFFICIENTS



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 6 – CURRENT-GAIN–BANDWIDTH PRODUCT

FIGURE 7 – CAPACITANCE

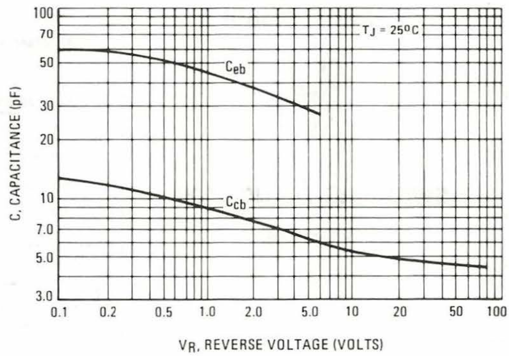


FIGURE 8 – TURN-ON TIME

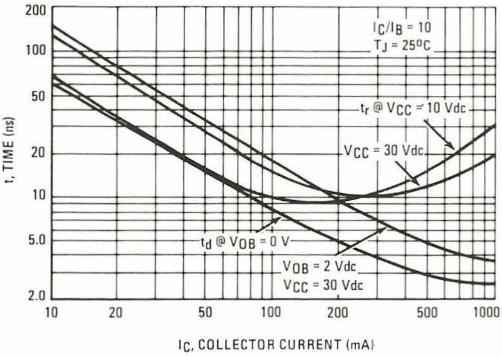


FIGURE 9 – TURN-OFF TIME

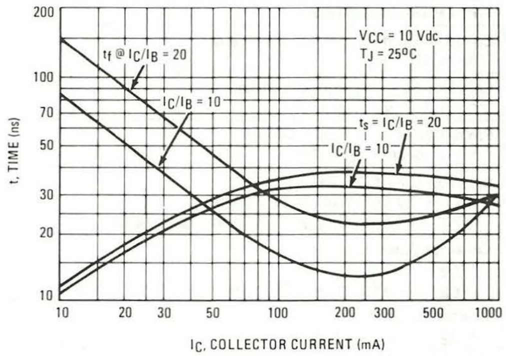


FIGURE 10 – TURN-ON TIME TEST CIRCUIT

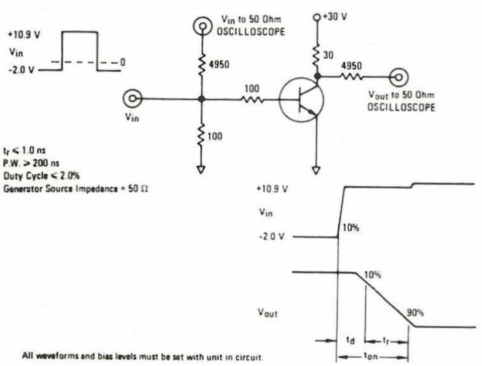
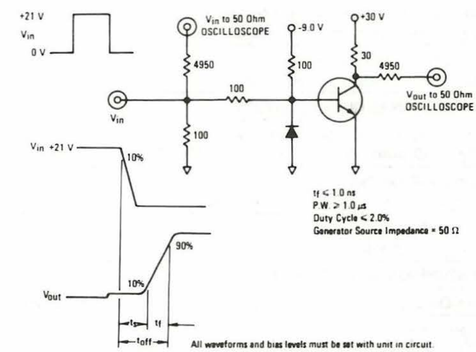
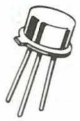


FIGURE 11 – TURN-OFF TIME TEST CIRCUIT



2N5861

CASE 79-02, STYLE 1
TO-39 (TO-205AD)



SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CBO}	100	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	2.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 6.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	50	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	100	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CE} = 50 Vdc, $V_{BE(off)}$ = 2.0 Vdc) (V_{CE} = 50 Vdc, $V_{BE(off)}$ = 2.0 Vdc, T_A = 75°C)	I_{CEX}	 — —	 0.3 10	μAdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = +75°C)	I_{CBO}	 — —	 0.3 10	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = 500 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C)	h_{FE}	 25 10	 100 —	—
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	0.8	1.1	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	200	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	—	7.0	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{eb}	—	60	pF

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
Turn-On Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc)	t_{on}	—	25	ns
Delay Time		t_d	—	8.0	ns
Rise Time		t_r	—	18	ns

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Turn-Off Time	(V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_{off}	—	60	ns
Storage Time		t_s	—	35	ns
Fall Time		t_f	—	35	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%

TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 1 – CURRENT-GAIN–BANDWIDTH PRODUCT

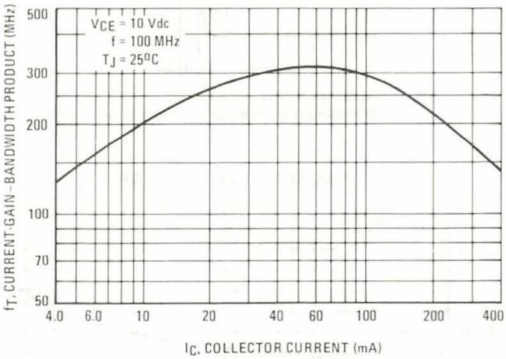


FIGURE 2 – CAPACITANCE

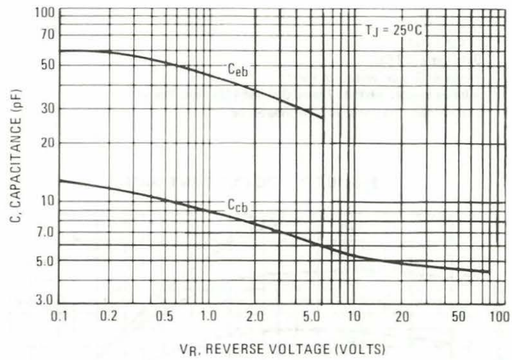


FIGURE 3 – TURN-ON TIME

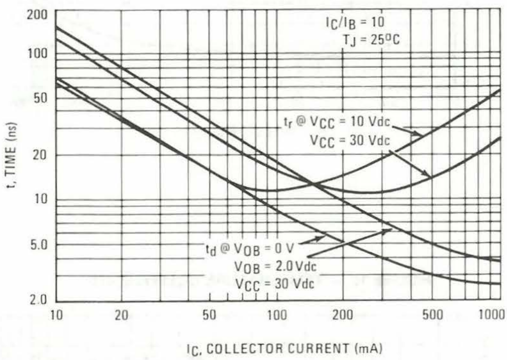


FIGURE 4 – TURN-OFF TIME

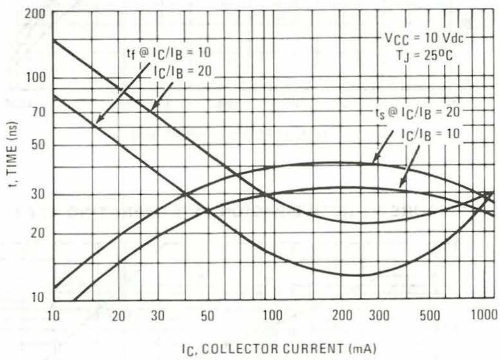
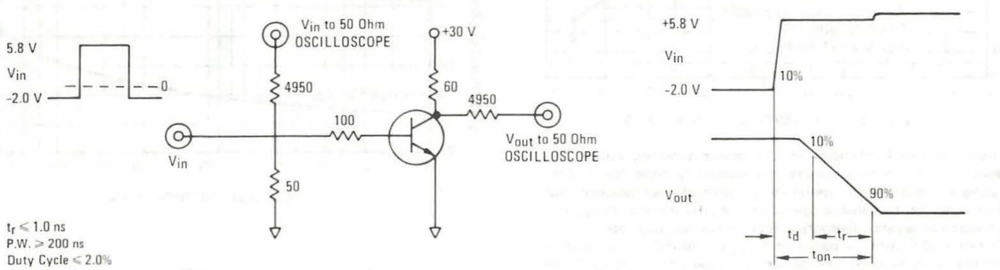


FIGURE 5 – TURN-ON TIME TEST CIRCUIT

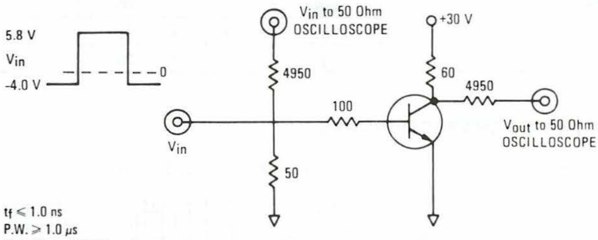


t_r ≤ 1.0 ns
P.W. ≥ 200 ns
Duty Cycle ≤ 2.0%
Generator Source Impedance = 50 Ω
Pulse Generator: EH1421 Timing Unit and 1121 Pulse Driver
Oscilloscope: Tektronix 661 Sampling Scope

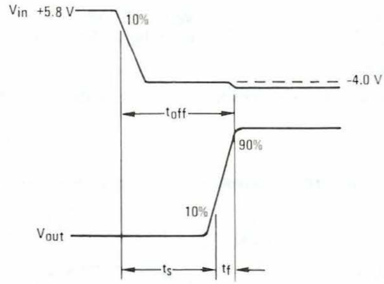
V_{in} during t_{on} interval must be +5.8 V.
All waveforms and bias levels must be set with unit in circuit.

4

FIGURE 6 – TURN-OFF TIME TEST CIRCUIT



$t_f \leq 1.0$ ns
P.W. $\geq 1.0\ \mu s$
Duty Cycle $\leq 2.0\%$
Generator Source Impedance = 50 Ω
Pulse Generator: EH1421 Timing Unit and 1121 Pulse Driver
Oscilloscope: Tektronix 661 Sampling Scope



V_{in} during t_{off} interval must be -4.0 V.
All waveforms and bias levels must be set with unit in circuit.

FIGURE 7 – DC CURRENT GAIN

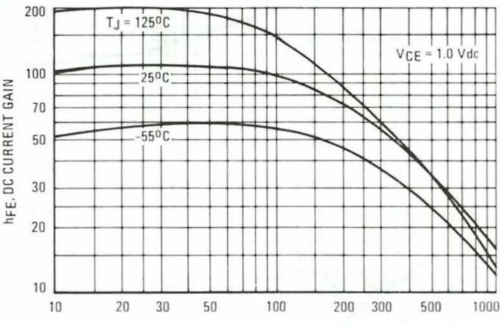


FIGURE 8 – "ON" VOLTAGES

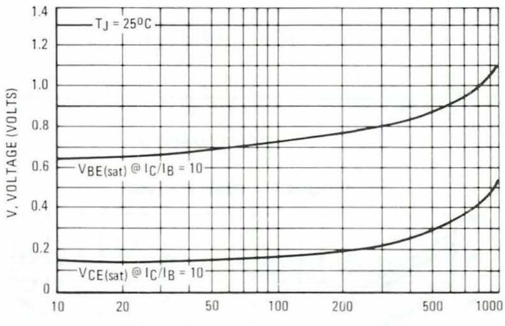
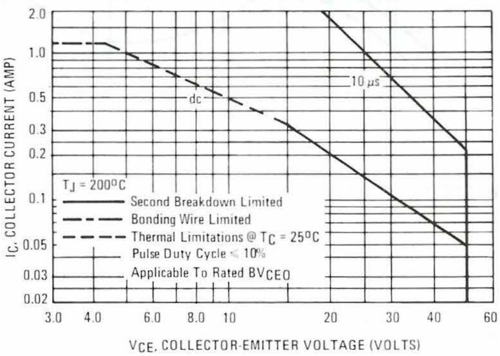


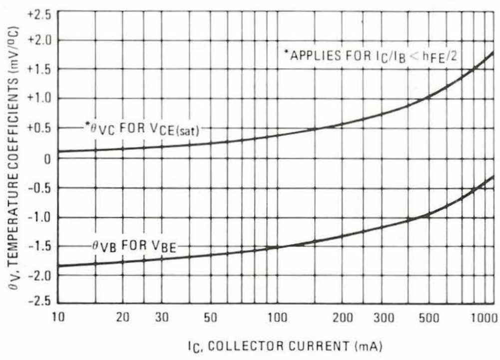
FIGURE 9 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 9 is based on $T_{J(pk)} = 200°C$; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 200°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 10 — TEMPERATURE COEFFICIENTS



2N6430
2N6431

CASE 22, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	2N6430	2N6431	Unit
Collector-Emitter Voltage	V_{CEO}	200	300	Vdc
Collector-Base Voltage	V_{CBO}	200	300	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	50		mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	500 2.86		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.8 10.3		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	 2N6430 2N6431	$V_{(BR)CEO}$	 200 300	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	 2N6430 2N6431	$V_{(BR)CBO}$	 200 300	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 160$ Vdc) ($V_{CB} = 200$ Vdc)	 2N6430 2N6431	I_{CBO}	 — —	 0.1 0.1	μAdc
Emitter Cutoff Current ($V_{EB} = 4.0$ Vdc, $I_C = 0$)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)		h_{FE}	 25 40 50	 — — 200	—
Collector-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)		f_T	50	500	MHz
Collector-Base Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{cb}	—	4.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N6432
2N6433

CASE 22, STYLE 1
TO-18 (TO-206AA)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to 2N3743 for graphs.

4

MAXIMUM RATINGS

Rating	Symbol	2N6432	2N6433	Unit
Collector-Emitter Voltage	V_{CEO}	200	300	Vdc
Collector-Base Voltage	V_{CBO}	200	300	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	500 2.86		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.8 10.3		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	 2N6432 2N6433	$V_{(BR)CEO}$	 200 300	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	 2N6432 2N6433	$V_{(BR)CBO}$	 200 300	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 160$ Vdc) ($V_{CB} = 200$ Vdc)	 2N6432 2N6433	I_{CBO}	 — —	 0.25 0.25	μAdc
Emitter Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)		h_{FE}	 25 40 30	 — — 150	—
Collector-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 20 MHz)		f_T	50	500	MHz
Collector-Base Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{cb}	—	6.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MM420
MM421

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

TRANSISTOR

NPN SILICON

Refer to 2N3439 for graphs.

4

MAXIMUM RATINGS

Rating	Symbol	MM420	MM421	Unit
Collector-Emitter Voltage	V_{CEO}	250	325	Vdc
Collector-Base Voltage	V_{CBO}	275	350	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	6.0	Vdc
Base Current	I_B	100	100	mA
Collector Current — Continuous	I_C	100	500	mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	800 5.3		mW mW/°C
Total Device Dissipation @ $T_A = 75°C$ Derate above 75°C	P_D	2.5 25		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +175		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) ($I_C = 10$ mA, $I_B = 0$)	 MM420 MM421	$V_{CEO(sus)}$	 250 325	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc)	 MM420 MM421	$V_{(BR)CBO}$	 275 350	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc)		$V_{(BR)EBO}$	6	—	Vdc
Collector Cutoff Current ($V_{CE} = 250$ Vdc, $I_B = 0$) ($V_{CE} = 325$ Vdc, $I_B = 0$)	 MM420 MM421	I_{CEO}	 — —	 1.0 1.0	mAdc
Collector Cutoff Current ($V_{BE} = 275$ Vdc, $I_E = 0$) ($V_{BE} = 350$ Vdc, $I_E = 0$)	 MM420 MM421	I_{CBO}	 — —	 100 100	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 20$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 20$ Vdc)		h_{FE}	 15 25 25	 — — 250	—
Collector-Emitter Saturation Voltage ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc)		$V_{CE(sat)}$	—	5.0	Vdc
Base-Emitter On Voltage ($I_C = 30$ mA, $V_{CE} = 20$ V)		$V_{BE(on)}$	—	1.0	V
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mA, $V_{CE} = 20$ V, f = 10 MHz)		f_T	15	—	MHz
Output Capacitance ($V_{CB} = 20$ V, f = 100 kHz)	(Common Base)	C_{obo}	—	12	pF

(1) PW ≤ 300 μsec, Duty Cycle ≤ 2.0%.

MM1505

CASE 27-02, STYLE 1
TO-52 (TO-206AC)

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage(1)	V_{CEO}	6.0	Vdc
Collector-Emitter Voltage	V_{CES}	11	Vdc
Collector-Base Voltage	V_{CBO}	15	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.30 1.71	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C
Lead Temperature (Soldering, 60 second time limit)	T_L	300	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 10\ \mu Adc$, $V_{BE} = 0$)	$V_{(BR)CES}$	11	—	Vdc
Collector-Emitter Sustaining Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{CEO(sus)}$	6.0	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu Adc$, $I_E = 0$)	$V_{(BR)CBO}$	15	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu Adc$, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 11$ Vdc, $V_{BE} = 0$) ($V_{CE} = 5.0$ Vdc, $V_{BE} = 0$) ($V_{CE} = 5.0$ Vdc, $V_{BE} = 0$, $T_A = +85°C$)	I_{CES}	— — —	10 0.1 5.0	μAdc
Base Cutoff Current ($V_{CE} = 11$ Vdc, $V_{EB(off)} = 0$)	I_{BL}	—	10	μAdc
ON CHARACTERISTICS(2)				
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 0.4$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 0.4$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 0.4$ Vdc)	h_{FE}	15 25 15	— 125 —	—
Collector-Emitter Saturation Voltage ($I_C = 1.0$ mAdc, $I_B = 0.1$ mAdc) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc, $T_A = 85°C$)	$V_{CE(sat)}$	— — — —	0.25 0.25 0.38 0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 1.0$ mAdc, $I_B = 0.1$ mAdc) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc)	$V_{BE(sat)}$	0.68 0.75 —	0.85 0.95 1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 4.0$ Vdc, f = 100 MHz)	f_T	600	—	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 140 kHz)	C_{obo}	—	3.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 140 kHz)	C_{ibo}	—	2.0	pF
SWITCHING CHARACTERISTICS				
Storage Time ($I_C = I_{B1} \approx I_{B2} = 5.0$ mAdc)	t_s	—	6.0	ns
Turn-On Time ($V_{CC} = 1.0$ Vdc, $V_{BE(off)} = 1.0$ Vdc, $I_C = 10$ mAdc, $I_{B1} \approx 2.0$ mAdc)	t_{on}	—	12	ns
Turn-Off Time ($V_{CC} = 1.0$ Vdc, $I_C = 10$ mAdc, $I_{B1} \approx I_{B2} \approx 1.0$ mAdc)	t_{off}	—	12	ns

(1) Applicable from 0.01 mAdc to 10 mAdc (Pulsed).
(2) Pulse Test: Pulse Length = 300 μs, Duty Cycle ≤ 2.0%.

MM1748,A

CASE 27, STYLE 1
TO-52 (TO-206AC)

SWITCHING TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	$V_{CEO(sus)}$	6.0	Vdc
Collector-Base Voltage	V_{CBO}	15	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	150	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.71	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	583	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

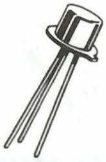
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage(2) (I_C = 10 mAdc, I_B = 0)		$V_{CEO(sus)}$	6.0	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	15	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 5.0 Vdc, I_E = 0)	MM1748 MM1748A	I_{CBO}	— —	— —	50 5.0	nAdc
(V_{CB} = 5.0 Vdc, I_E = 0, T_A = 150°C)	Both Devices		—	—	5.0	μAdc
ON CHARACTERISTICS(2)						
DC Current Gain (I_C = 10 mAdc, V_{CE} = 0.5 Vdc)	MM1748 MM1748A	h_{FE}	20 30	50 55	120 90	—
(I_C = 10 mAdc, V_{CE} = 0.5 Vdc, T_A = −55°C) (I_C = 30 mAdc, V_{CE} = 1.0 Vdc)	Both Devices Both Devices		10 15	20 20	— —	
Collector-Emitter Saturation Voltage (I_C = 3.0 mAdc, I_B = 0.15 mAdc)		$V_{CE(sat)}$	—	0.2	0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 3.0 mAdc, I_B = 0.15 mAdc)		$V_{BE(sat)}$	0.7	0.78	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 4.0 Vdc, f = 100 MHz)	MM1748 MM1748A	f_T	600 800	750 850	— —	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)		C_{obo}	—	2.0	3.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)		C_{ibo}	—	1.8	2.0	pF
SWITCHING CHARACTERISTICS						
Storage Time (V_{CC} = 3.0 Vdc, I_C = 5.0 mAdc, I_{B1} = I_{B2} = 5.0 mAdc)		t_s	—	4.0	6.0	ns
Turn-On Time (V_{CC} = 1.0 Vdc, $V_{BE(off)}$ = 1.0 Vdc, I_C = 10 mAdc, I_{B1} = 2.0 mAdc, I_{B2} = 1.0 mAdc)		t_{on}	—	12	15	ns
Turn-Off Time (V_{CC} = 1.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)		t_{off}	—	12	15	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MM2005

CASE 22-03, STYLE 1
TO-18 (TO-206AA)



AMPLIFIER TRANSISTOR

PNP SILICON

4

Refer to 2N2904 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	600	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	400 2.28	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.4 8.0	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	25	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	—	0.5	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	100	200	400	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{CE(sat)}$	—	0.3	1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{BE(sat)}$	—	0.7	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	6.0	15	pF
SWITCHING CHARACTERISTICS					
Turn-On Time ($V_{CC} = 30$ Vdc, $I_C = 150$ mAdc, $I_{B1} = 15$ mAdc)	t_{on}	—	20	45	μs
Turn-Off Time ($V_{CC} = 6.0$ Vdc, $I_C = 150$ mAdc, $I_{B1} = I_{B2} = 15$ mAdc)	t_{off}	—	85	100	μs

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MM2258
MM2259
MM2260

CASE 31-03, STYLE 1
TO-5 (TO-205AA)

TRANSISTOR

NPN SILICON

Refer to 2N3498 for graphs.

4

MAXIMUM RATINGS

Rating	Symbol	MM2258	MM2259 MM2260	Unit
Collector-Emitter Voltage	V_{CEO}	120	175	Vdc
Collector-Base Voltage	V_{CBO}	120	175	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500	300	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	MM2258	MM2259 MM2260	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35		°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175		°C/W

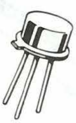
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	 MM2258 MM2259, MM2260	$V_{(BR)CEO}$	 120 175	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	 MM2258 MM2259, MM2260	$V_{(BR)CBO}$	 120 175	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 75 V, I_E = 0) (V_{CB} = 75 V, I_E = 0, 50°C)		I_{CBO}	 — —	 .050 50	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	—	25	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 50 mAdc, V_{CE} = 10 Vdc)	 MM2259 MM2258, MM2260 MM2259 MM2258, MM2260 MM2259 MM2258, MM2260	h_{FE}	 25 50 35 50 35 50	 — — — — — —	—
Collector-Emitter Saturation Voltage (I_C = 25 mAdc, I_B = 2.5 mAdc)		$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 25 mAdc, I_B = 2.5 mAdc)		$V_{BE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	 MM2258 MM2259, MM2260	C_{obo}	 — —	 9.0 8.0	pF
Collector-Base Capacitance (V_{CB} = 25 Vdc, I_C = 10 mAdc)	 MM2258 MM2259, MM2260	C_{cb}	 — —	 5.0 4.5	pF
Magnitude of Forward Current Transfer Ratio, Common-Emitter (V_{CE} = 25 Vdc, I_C = 20 mAdc, f = 100 MHz)		$\|h_{fe}\|$	1.5	—	—

(1) Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2.0%.

MM3000 thru MM3003

CASE 79, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MM3000	MM3001	MM3002	MM3003	Unit
Collector-Emitter Voltage	V_{CEO}	100	150	200	250	Vdc
Emitter-Base Voltage	V_{EBO}	5.0				Vdc
Collector Current — Continuous	I_C	200	200	50	50	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71				Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6				Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200				°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	100		Vdc
	MM3000		100	—	
	MM3001		150	—	
	MM3002		200	—	
	MM3003		250	—	
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current		I_{CBO}			μAdc
($V_{CB} = 50$ Vdc, $I_E = 0$)	MM3000		—	1.0	
($V_{CB} = 75$ Vdc, $I_E = 0$)	MM3001		—	1.0	
($V_{CB} = 100$ Vdc, $I_E = 0$)	MM3002, MM3003		—	5.0	
ON CHARACTERISTICS					
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)		h_{FE}	20	—	—
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)		f_T	150	—	MHz
Output Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 100 kHz)		C_{obo}			pF
	MM3000, MM3001		—	7.0	
	MM3002, MM3003		—	15	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MM3005
MM3006
MM3007

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

AUDIO TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	MM3005	MM3006	MM3007	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	100	Vdc
Collector-Base Voltage	V_{CBO}	80	100	120	Vdc
Emitter-Base Voltage	V_{EBO}		5.0		Vdc
Collector Current — Continuous	I_C		2.5		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D		1.0 5.71		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D		8.0 45.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

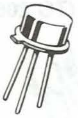
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	MM3005 MM3006 MM3007	$V_{(BR)CEO}$	60 80 100	— — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MM3005 MM3006 MM3007	$V_{(BR)CBO}$	80 100 120	— — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 80 Vdc, I_E = 0) (V_{CB} = 100 Vdc, I_E = 0)	MM3005 MM3006 MM3007	I_{CBO}	— — —	100 100 100	nAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 150 mAdc, V_{CE} = 1.0 Vdc) (I_C = 200 mAdc, V_{CE} = 1.0 Vdc) (I_C = 250 mAdc, V_{CE} = 1.0 Vdc)	All Types MM3005 MM3006 MM3007	h_{FE}	40 50 50 50	— 250 250 250	—
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$	—	0.35	Vdc
Base-Emitter On Voltage (I_C = 150 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	0.60	0.75	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	50	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	15	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

4

MM3008
MM3009

CASE 79-02, STYLE 1
TO-39 (TO-205AD)



TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MM3008	MM3009	Unit
Collector-Emitter Voltage	V_{CEO}	120	180	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	400		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	4.0 22.8		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

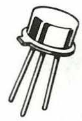
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	 MM3008 MM3009	$V_{(BR)CEO}$	 120 180	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 120$ Vdc, $I_E = 0$) ($V_{CB} = 180$ Vdc, $I_E = 0$)	 MM3008 MM3009	I_{CBO}	 — —	 0.1 0.1	μAdc
Emitter Cutoff Current ($V_{BE} = 4.0$ Vdc, $I_C = 0$)		I_{EBO}		0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)		h_{FE}	 30 40 30	 — — —	—
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 20$ mAdc, $V_{CE} = 20$ Vdc, f = 20 MHz)		f_T	50	—	MHz
Output Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	4.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)		C_{ibo}	—	20	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MM3726

CASE 79-02, STYLE 1
TO-39 (TO-205AD)



SWITCHING TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CBO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	1.5	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W

Refer to 2N3467 for graphs.

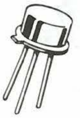
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	50	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 40$ Vdc, $I_E = 0$)	I_{CBO}	—	0.1	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain ($I_C = 500$ mAdc, $V_{CE} = 2.0$ Vdc) ($I_C = 1.0$ Adc, $V_{CE} = 5.0$ Vdc)	h_{FE}	 30 15	 120 —	—
Collector-Emitter Saturation Voltage ($I_C = 500$ mAdc, $I_B = 50$ mAdc) ($I_C = 1.0$ Adc, $I_B = 100$ mAdc)	$V_{CE(sat)}$	 — —	 0.6 1.2	Vdc
Base-Emitter Saturation Voltage ($I_C = 500$ mAdc, $I_B = 50$ mAdc) ($I_C = 1.0$ Adc, $I_B = 100$ mAdc)	$V_{BE(sat)}$	 0.8 —	 1.1 1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(1) ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	200	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz, emitter guarded)	C_{cb}	—	10	pF
Emitter-Base Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz, collector guarded)	C_{eb}	—	80	pF
SWITCHING CHARACTERISTICS				
Turn-On Time ($V_{CC} = 30$ Vdc, $V_{BE(off)} = 2.0$ Vdc, $I_C = 500$ mAdc, $I_{B1} = 50$ mAdc, $R_B = 200$ ohms, $R_L = 60$ ohms)	t_{on}	—	30	ns
Turn-Off Time ($V_{CC} = 30$ Vdc, $I_C = 500$ mAdc, $I_{B1} = I_{B2} = 50$ mAdc, $R_B = 200$ ohms, $R_L = 60$ ohms)	t_{off}	—	90	ns
Turn-On Time ($V_{CC} = 30$ Vdc, $V_{BE} = 2.0$ Vdc, $I_C = 1.0$ Adc, $I_{B1} = 100$ mAdc, $R_B = 100$ ohms, $R_L = 30$ ohms)	t_{on}	—	35	ns
Turn-Off Time ($V_{CC} = 30$ Vdc, $I_C = 1.0$ Adc, $I_{B1} = I_{B2} = 100$ mAdc, $R_B = 100$ ohms, $R_L = 30$ ohms)	t_{off}	—	60	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MM3903
MM3904

CASE 27-02, STYLE 1
TO-52 (TO-206AC)



4

GENERAL PURPOSE TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 2.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	500 5.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +125	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	490	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	Vdc
Base Cutoff Current (V_{CE} = 30 Vdc, $V_{EB(off)}$ = 3.0 Vdc)		I_{BEV}	—	50	nAdc
Collector Cutoff Current (V_{CE} = 30 Vdc, $V_{EB(off)}$ = 3.0 Vdc)		I_{CEX}	—	50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain		h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	MM3903 MM3904		20 40	— —	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	MM3903 MM3904		35 70	— —	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	MM3903 MM3904		50 100	150 300	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	MM3903 MM3904		30 60	— —	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	MM3903 MM3904		10 15	— —	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	 — —	 0.2 0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{BE(sat)}$	 0.65 —	 0.85 0.95	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MM3903 MM3904	f_T	250 300	— —	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	8.0	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MM3903 MM3904	h_{fe}	50 100	200 400	—
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_d	—	35	ns
Rise Time		t_r	—	35	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc) MM3903 MM3904	t_s	— —	175 200	ns
Fall Time		t_f	—	50	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MM3905
MM3906

CASE 27-02, STYLE 1
TO-52 (TO-206AC)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to 2N3250 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.06	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	490	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Base Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 3.0 Vdc)		I_{BEV}	—	50	nAdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 3.0 Vdc)		I_{CEV}	—	50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain		h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	MM3905 MM3906		30 60	— —	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	MM3905 MM3906		40 80	— —	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	MM3905 MM3906		50 100	150 300	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	MM3905 MM3906		30 60	— —	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	MM3905 MM3906		10 15	— —	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	— —	0.25 0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{BE(sat)}$	0.65 —	0.85 0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MM3905 MM3906	f_T	200 250	— —	MHz

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	5.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	10	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MM3905 MM3906	h_{ie}	0.5 2.0	8.0 12	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MM3905 MM3906	h_{re}	0.1×10^{-4} 1×10^{-4}	5×10^{-4} 10×10^{-4}	—
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MM3905 MM3906	h_{fe}	50 100	200 400	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MM3905 MM3906	h_{oe}	1.0 3.0	40 60	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohm, f = 10 Hz to 15.7 kHz)	MM3905 MM3906	NF	— —	5.0 4.0	dB

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
Delay Time	(V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_d	—	35	ns
Rise Time		t_r	—	35	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc) MM3905 MM3906	t_s	— —	200 225	ns
Fall Time	MM3905 MM3906	t_f	— —	60 75	ns

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

4

MM4000 thru MM4003

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

GENERAL PURPOSE TRANSISTOR

PNP SILICON

Refer to 2N3494 for graphs for MM4000.*

MAXIMUM RATINGS

Rating	Symbol	MM4000	MM4001	MM4002	MM4003	Unit
Collector-Emitter Voltage	V_{CEO}	100	150	200	250	Vdc
Collector-Base Voltage	V_{CBO}	100	150	200	250	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	4.0	4.0	4.0	Vdc
Collector Current — Continuous	I_C	100	500	500	500	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.6 3.42	1.0 5.71	1.0 5.71	1.0 5.71	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	3.0 17.2	5.0 28.6	5.0 28.6	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200				°C

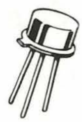
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	MM4000 MM4001 MM4002 MM4003	$V_{(BR)CEO}$	100 150 200 250	— — — —	Vdc
Collector-Base Breakdown Voltage (I_E = 0, I_C = 100 μAdc)	MM4000 MM4001 MM4002 MM4003	$V_{(BR)CBO}$	100 150 200 250	— — — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 75 Vdc, I_E = 0) (V_{CB} = 150 Vdc, I_E = 0)	 MM4000 MM4001 MM4002, MM4003	I_{CBO}	— — —	1.0 1.0 5.0	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 10 Vdc)		h_{FE}	20	—	—
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc)	MM4000, MM4001 MM4002, MM4003	$V_{CE(sat)}$	— —	0.6 5.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)	MM4000 MM4001 MM4002, MM4003	C_{obo}	— — —	6.0 10 20	pF

(1) Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2.0%.
*Refer to 2N3634 for graphs for MM4001.
Refer to 2N4930 for graphs for MM4002 and MM4003.

MM4005 thru MM4007

CASE 79-02, STYLE 1
TO-39 (TO-205AD)



AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N4033 for graphs.

4

MAXIMUM RATINGS

Rating	Symbol	MM4005	MM4006	MM4007	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	100	Vdc
Collector-Base Voltage	V_{CBO}	60	80	100	Vdc
Emitter-Base Voltage	V_{EBO}		5.0		Vdc
Collector Current — Continuous	I_C		1.0		Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D		1.0 5.71		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D		7.0 40		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	25	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	175	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

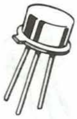
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)	MM4005 MM4006 MM4007	$V_{(BR)CEO}$	60 80 100	— — —	— — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	MM4005 MM4006 MM4007	$V_{(BR)CBO}$	60 80 100	— — —	— — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$) ($V_{CB} = 60$ Vdc, $I_E = 0$) ($V_{CB} = 80$ Vdc, $I_E = 0$)	MM4005 MM4006 MM4007	I_{CBO}	— — —	— — —	100 100 100	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS(2)						
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 1.0$ Vdc)		h_{FE}	40 50	90 150	— —	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)		$V_{CE(sat)}$	—	0.1	—	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)		$V_{BE(sat)}$	—	0.7	—	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(2) ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)		f_T	50	250	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	10	—	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)		C_{ibo}	—	100	—	pF

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MM4036
MM4037

CASE 79-02, STYLE 1
TO-39 (TO-205AD)



SWITCHING TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage MM4036 MM4037	V_{CEO}	 65 40	Vdc
Collector-Base Voltage MM4036 MM4037	V_{CBO}	 90 60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Base Current	I_B	500	mAdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	7.0 40	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	25	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	175	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	 MM4036 MM4037	$V_{(BR)CEO}$	 65 40	 —	 —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0) (I_C = 10 μAdc, I_E = 0)	 MM4036 MM4037	$V_{(BR)CBO}$	 90 60	 — —	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0) (I_E = 1.0 μAdc, I_C = 0)	 MM4036 MM4037	$V_{(BR)EBO}$	 5.0 5.0	 — —	 — —	Vdc
Collector Cutoff Current(1) (V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc) (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	 MM4036 MM4036	I_{CEV}	 — —	 — —	 250 100	 nAdc μAdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)	 MM4036, MM4037	I_{CBO}	—	—	250	 nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0) (V_{BE} = 5.0 Vdc, I_C = 0)	 MM4036 MM4037	I_{EBO}	 — —	 — —	 250 1.0	μAdc
ON CHARACTERISTICS(2)						
DC Current Gain (I_C = 100 μAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 2.0 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc) (I_C = 500 mAdc, V_{CE} = 10 Vdc) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc)	 MM4036 MM4036 MM4036 MM4036 MM4037 MM4037	h_{FE}	 20 20 40 20 15 50	 50 60 90 40 50 75	 — 200 140 — — 250	—
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	 MM4036 MM4037	$V_{CE(sat)}$	 —	 0.3 0.3	 0.65 1.4	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$	—	1.0	1.4	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

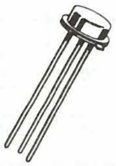
Characteristic		Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(2) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	60	100	—	MHz
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	MM4036, MM4037	C_{ibo}	—	60	—	pF
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	MM4036 MM4037	C_{cb}	— —	20 20	— 30	pF
SWITCHING CHARACTERISTICS						
Turn-On Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_{on}	—	40	75	ns
Turn-Off Time	(V_{CC} = 6.0 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_{off}	—	110	175	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

4

MM4052

CASE 26-03, STYLE 1
TO-46 (TO-206AB)



CHOPPER AND SWITCHING TRANSISTOR

PNP SILICON

Refer to 2N2944A for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Emitter-Collector Voltage	V_{ECO}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	30	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.5 2.86	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.75 10	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	30	—	Vdc
Emitter-Collector Breakdown Voltage(1) ($I_E = 10$ mAdc, $I_B = 0$)	$V_{(BR)ECO}$	30	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	30	—	Vdc
Emitter-Base Breakdown Voltage(1) ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	30	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	0.5	nAdc
Emitter Cutoff Current ($V_{EB} = 15$ Vdc, $I_C = 0$)	I_{EBO}	—	0.5	nAdc
ON CHARACTERISTICS				
DC Current Gain(1) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 1.0$ Vdc) (Inverted)	h_{FE}	 20 15 3.0	 — — —	—
Offset Voltage ($I_B = 1.0$ mAdc, $I_E = 0$)	$V_{EC(ofs)}$	—	2.0	mVdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, 100 kHz $\leq f \leq$ 1.0 MHz)	C_{obo}	—	10	pF
Input Capacitance ($V_{EB} = 10$ Vdc, $I_C = 0$, 100 kHz $\leq f \leq$ 1.0 MHz)	C_{ibo}	—	5.0	pF
Small-Signal Current Gain ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc, f = 1.0 kHz) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc, f = 4.0 MHz)	h_{fe}	 20 3.0	 — —	—
"ON" Series Resistance ($I_B = 10$ mAdc, f = 1.0 kHz)	r_{ec}	—	2.0	Ohms

(1) Pulse Test: Pulse Width $\leq$ 300 μs, Duty Cycle $\leq$ 20%.

MM4208
MM4209

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

PNP SILICON

Refer to MM4257 for graphs.

4

MAXIMUM RATINGS

Rating	Symbol	MM4208	MM4209	Unit
Collector-Emitter Voltage	V_{CEO}	12	15	Vdc
Collector-Base Voltage	V_{CBO}	12	15	Vdc
Emitter-Base Voltage	V_{EBO}	4.5		Vdc
Collector Current — Continuous	I_C	200		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.36 2.06		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.2 6.86		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) ($I_C = 3.0$ mAdc, $I_B = 0$)	 MM4208 MM4209	$V_{(BR)CEO}$	 12 15	 — —	 — —	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100$ μAdc, $V_{BE} = 0$)	 MM4208 MM4209	$V_{(BR)CES}$	 12 15	 — —	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	 MM4208 MM4209	$V_{(BR)CBO}$	 12 15	 — —	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	4.5	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 6.0$ Vdc, $V_{BE} = 0$) ($V_{CE} = 8.0$ Vdc, $V_{BE} = 0$) ($V_{CE} = 6.0$ Vdc, $V_{BE} = 0$, $T_A = 125°C$) ($V_{CE} = 8.0$ Vdc, $V_{BE} = 0$, $T_A = 125°C$)	 MM4208 MM4209 MM4208 MM4209	I_{CES}	 — — — —	 — — — —	 10 10 5.0 5.0	nAdc μAdc
Base Current ($V_{CE} = 6.0$ Vdc, $V_{BE} = 0$) ($V_{CE} = 8.0$ Vdc, $V_{BE} = 0$)	 MM4208 MM4209	I_B	 — —	 — —	 1.0 1.0	nAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 0.5$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc, $T_A = -55°C$) ($I_C = 50$ mAdc, $V_{CE} = 1.0$ Vdc)(1)	 MM4208 MM4209 MM4208 MM4209 MM4208 MM4209 MM4208 MM4209	h_{FE}	 15 35 30 40 12 20 30 30	 — — — — — — — —	 — — 100 120 — — — —	—
Collector-Emitter Saturation Voltage ($I_C = 1.0$ mAdc, $I_B = 0.1$ mAdc) ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)(1) ($I_C = 1.0$ mA, $I_B = 0.1$ mA) ($I_C = 10$ mA, $I_B = 1.0$ mA)	 MM4208 MM4208 MM4208, MM4209 MM4209 MM4209	$V_{CE(sat)}$	 — — — — —	 — — — — —	 0.13 0.15 0.6 0.15 0.18	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Base-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)(1)		$V_{BE(sat)}$	 — 0.75 —	 — — —	 0.8 .95 1.5	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	 MM4208	f_T	850 700	1300 1200	— —	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)		C_{obo}	—	—	3.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)		C_{ibo}	—	—	3.5	pF
SWITCHING CHARACTERISTICS						
Turn-On Time		t_{on}	—	—	15	ns
Turn-Off Time		t_{off}	—	—	25	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

MM4257
MM4258

CASE 22, STYLE 1
TO-18 (TO-206AA)

SWITCHING TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	MM4257	MM4258	Unit
Collector-Emitter Voltage	V_{CEO}	6.0	12	Vdc
Collector-Base Voltage	V_{CBO}	6.0	12	Vdc
Emitter-Base Voltage	V_{EBO}	4.5		Vdc
Collector Current — Continuous	I_C	200		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.06		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.86		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 100 μAdc, V_{BE} = 0)	 MM4257 MM4258	$V_{(BR)CES}$	 6.0 12	 — —	 — —	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 3.0 mAdc, I_B = 0)	 MM4257 MM4258	$V_{CEO(sus)}$	 6.0 12	 — —	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 MM4257 MM4258	$V_{(BR)CBO}$	 6.0 12	 — —	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	4.5	—	—	Vdc
Collector Cutoff Current (V_{CE} = 6.0 Vdc, V_{BE} = 0) (V_{CE} = 3.0 Vdc, V_{BE} = 0, T_A = +65°C)		I_{CES}	 — —	 — —	 0.01 5.0	μAdc
ON CHARACTERISTICS(1)						
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 0.5 Vdc) (I_C = 10 mAdc, V_{CE} = 0.3 Vdc) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	 15 30 30	 — — —	 — 120 —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	 — —	 — —	 0.15 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{BE(sat)}$	 0.75 —	 — —	 0.95 1.5	Vdc
SMALL SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(2) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	 MM4257 MM4258	f_T	 500 700	 — —	 — —	MHz
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	—	3.5	pF
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{cb}	—	—	3.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic			Symbol	Min	Typ	Max	Unit
SWITCHING CHARACTERISTICS							
Turn-On Time	(V_{CC} = 1.5 Vdc, V_{BE} = 0, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)		t_{on}	—	10	15	ns
Delay Time			t_d	—	5.0	10	ns
Rise Time			t_r	—	5.0	15	ns
Turn-Off Time	(V_{CC} = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	MM4257	t_{off}	—	12	15	ns
		MM4258		—	16	20	
Storage Time		MM4257	t_s	—	6.0	15	ns
		MM4258		—	8.0	20	
Fall Time		MM4257	t_f	—	6.0	10	ns
		MM4258			8.0	10	
Storage Time ($I_C \approx$ 10 mAdc, $I_{B1} \approx$ 10 mAdc, $I_{B2} \approx$ 10 mAdc)			t_s				ns
		MM4257		—	—	15	
		MM4258		—	—	20	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

TYPICAL TRANSIENT CHARACTERISTICS

FIGURE 1 — CURRENT-GAIN — BANDWIDTH PRODUCT

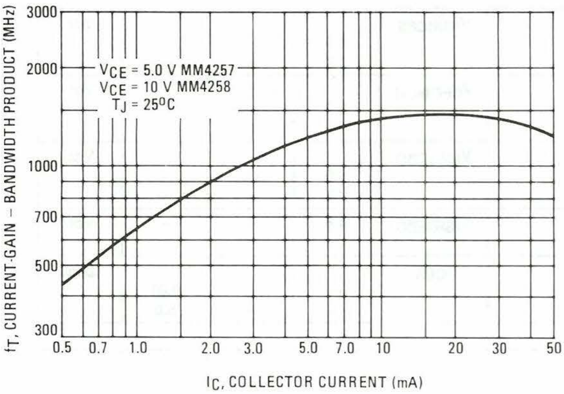


FIGURE 2 — CAPACITANCE

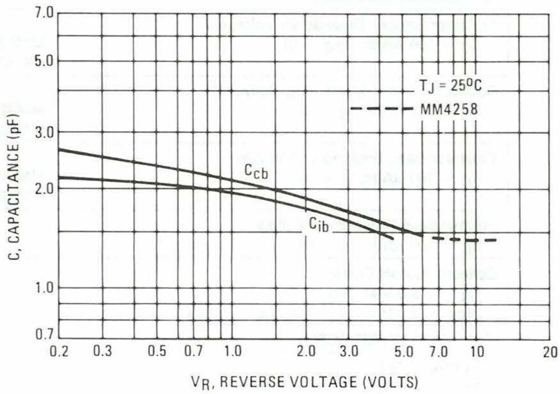


FIGURE 3 — TURN-ON TIME

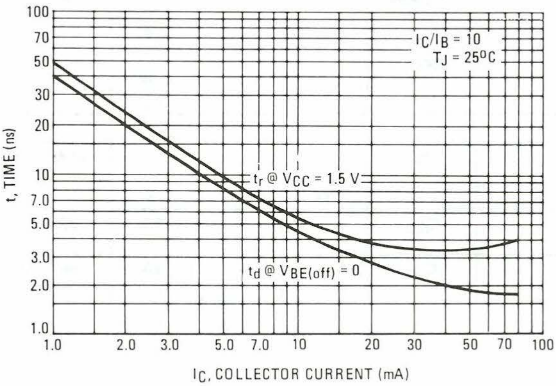
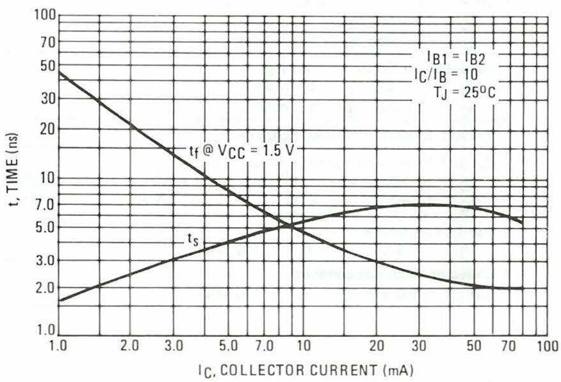
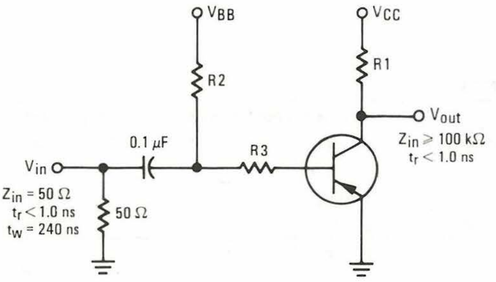


FIGURE 4 — TURN-OFF TIME



4

FIGURE 5 – SWITCHING TIME TEST CIRCUIT



	V_{in} Volts	V_{BB} Volts	V_{CC} Volts	R1 Ohms	R2 Ohms	R3 Ohms	I_C mA	I_{B1} mA	I_{B2} mA
t_{on}	-5.8	GND	-1.5	130	2.2 k	5 k	10	1.0	–
t_{off}	+9.8	-8.0	-1.5	130	2.2 k	5 k	10	1.0	1.0
t_s	+9.0	-10	-3.0	270	510	390	10	10	10

DC CURRENT GAIN

FIGURE 6 – MM4257

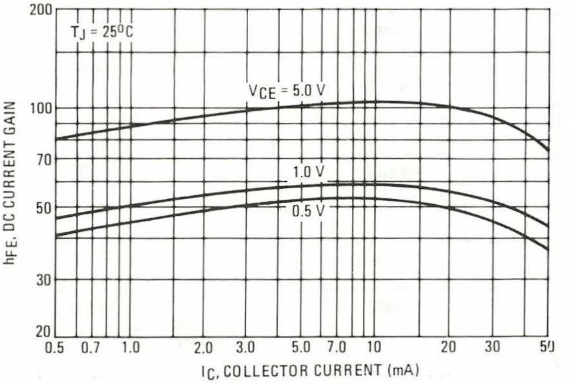


FIGURE 7 – MM4258

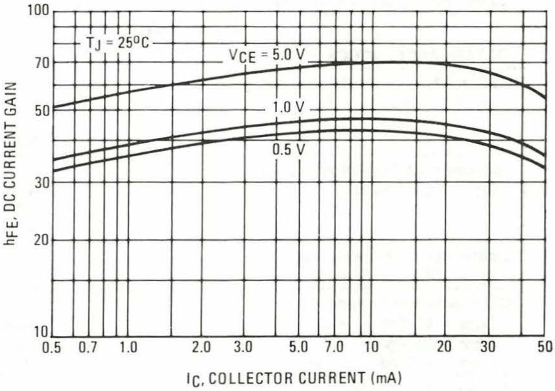
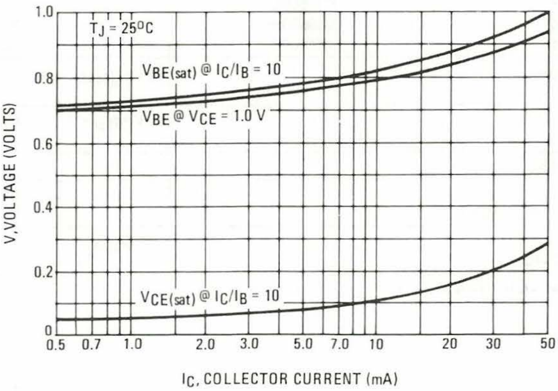
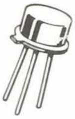


FIGURE 8 – "ON" VOLTAGES



MM5005
MM5006
MM5007

CASE 79-02, STYLE 1
TO-39 (TO-205AD)



AUDIO TRANSISTOR

PNP SILICON

4

MAXIMUM RATINGS

Rating	Symbol	MM5005	MM5006	MM5007	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	100	Vdc
Collector-Base Voltage	V_{CBO}	80	100	120	Vdc
Emitter-Base Voltage	V_{EBO}		5.0		Vdc
Collector Current — Continuous	I_C		2.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D		1.5 8.57		Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D		8.0 45.7		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−65 to +200		°C

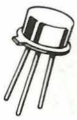
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	MM5005 MM5006 MM5007	$V_{(BR)CEO}$	60 80 100	— — —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MM5005 MM5006 MM5007	$V_{(BR)CBO}$	80 100 120	— — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 80 Vdc, I_E = 0) (V_{CB} = 100 Vdc, I_E = 0)	MM5005 MM5006 MM5007	I_{CBO}	— — —	200 200 200	nAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 150 mAdc, V_{CE} = 2.5 Vdc) (I_C = 200 mAdc, V_{CE} = 2.5 Vdc) (I_C = 250 mAdc, V_{CE} = 2.5 Vdc)	All Types MM5005 MM5006 MM5007	h_{FE}	40 50 50 50	— 250 250 250	—
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 150 mAdc, V_{CE} = 2.5 Vdc)		$V_{BE(on)}$	0.65	0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	30	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	20	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MM5262

CASE 79-02, STYLE 1
TO-39 (TO-205AD)



GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to 2N3724 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Emitter Voltage	V_{CES}	60	Vdc
Collector-Base Voltage	V_{CBO}	75	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	2.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	4.0 22.8	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	44	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	175	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

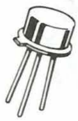
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	50	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	60	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	75	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 75 Vdc, I_E = 0)	I_{CBO}	—	—	100	μAdc
Collector Cutoff Current (V_{CE} = 60 Vdc, V_{BE} = 0)	I_{CES}	—	—	10	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	—	100	μAdc
ON CHARACTERISTICS(2)					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	h_{FE}	 35 40 25	 100 65 35	 — — —	—
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 100 mAdc)	$V_{CE(sat)}$	—	0.29	0.8	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 100 mAdc)	$V_{BE(sat)}$	—	0.94	1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	—	350	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	7.3	—	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	72	—	pF
SWITCHING CHARACTERISTICS					
Turn-On Time	t_{on}	—	16	30	ns
Turn-Off Time	t_{off}	—	28	60	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

4

MM5415
MM5416

CASE 79-02, STYLE 1
TO-39 (TO-205AD)



TRANSISTOR

PNP SILICON

Refer to 2N5415 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MM5415	MM5416	Unit
Collector-Emitter Voltage	V_{CEO}	200	300	Vdc
Collector-Base Voltage	V_{CBO}	200	350	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	7.0	Vdc
Base Current	I_B	0.5		Adc
Collector Current — Continuous	I_C	1.0		Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 6.7		Watt W/°C
Total Power Dissipation @ $T_C = 50°C$ Linear Derating Factor	P_D	10 0.057		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	17.5	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	150	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage ($I_C = 10$ mA, $I_B = 0$)	 MM5415 MM5416	$V_{CEO(sus)}$	 200 300	 — —	Vdc
Collector Cutoff Current ($V_{CE} = 150$ Vdc, $I_B = 0$)	 MM5415, MM5416	I_{CEO}	—	50	μAdc
Collector Cutoff Current ($V_{CE} = 175$ Vdc, $I_E = 0$) ($V_{CE} = 280$ Vdc, $I_E = 0$)	 MM5415 MM5416	I_{CBO}	 — —	 50 50	 μAdc μAdc
Emitter Cutoff Current ($V_{BE} = 4.0$ Vdc, $I_C = 0$) ($V_{BE} = 7.0$ Vdc, $I_C = 0$)	 MM5415 MM5416	I_{EBO}	 — —	 20 20	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc)	 MM5415 MM5416	h_{FE}	 30 30	 150 120	—
Collector-Emitter Saturation Voltage ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	 MM5415, MM5416	$V_{CE(sat)}$	—	2.5	Vdc
Base-Emitter On Voltage ($I_C = 50$ mAdc, $V_{CE} = 10$ V)	 MM5415, MM5416	$V_{BE(on)}$	—	1.5	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 5.0 MHz)		f_T	15	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, f = 1.0 MHz)		C_{obo}	—	25	pF
Current Gain — High Frequency ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)		$\lvert h_{fe} \rvert$	25	—	—
Real Part of Input Impedance ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 MHz)		$Re(h_{ie})$	—	300	Ohms

MM6427

CASE 22-03, STYLE 1
TO-18 (TO-206AA)

DARLINGTON TRANSISTOR

NPN SILICON

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	12	Vdc
Collector Current — Continuous	I_C	300	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	375 2.14	mW W/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.25 7.15	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

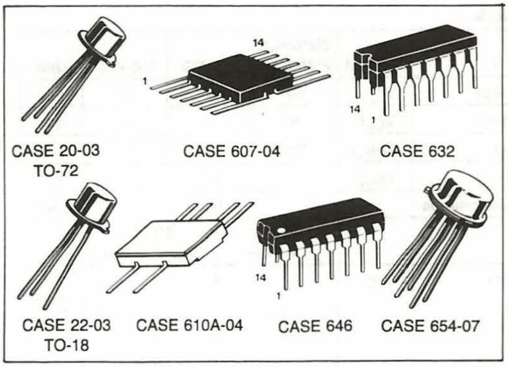
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	140	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	467	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	50	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	12	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	100	nAdc
Emitter Cutoff Current ($V_{BE} = 10$ Vdc, $I_C = 0$)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(1)				
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	 5000 10,000	 — —	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 0.1$ mAdc)	$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)	$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	8.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)	C_{ibo}	—	15	pF
Small-Signal Current Gain(1) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)	h_{fe}	1.25	—	—

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.



Motorola's multiple (Duals and Quads) transistors have been implemented with discrete transistor chips that have proven to be the most popular for all-around performance at low cost.

Packaging options include plastic and ceramic DIP's, ceramic flat pak, and various metal-can outlines.

Multiple Transistors

5

2N2060,A
2N2223,A
2N2480,A

2N2060 JAN, JTX, JTXV AVAILABLE
CASE 654-07, STYLE 1

DUAL AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MD2218 for graphs.

5

MAXIMUM RATINGS

Rating	Symbol	2N2060,A 2N2223,A	2N2480	2N2480A	Unit
Collector-Emitter Voltage	V_{CEO}	60	40	40	Vdc
Collector-Emitter Voltage	V_{CER}	80	—	—	Vdc
Collector-Base Voltage	V_{CBO}	100	75	80	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	5.0	5.0	Vdc
Collector Current — Continuous	I_C	500			mAdc

		One Die	All Die Equal Power	
Total Device Dissipation	P_D			
@ $T_A = 25°C$				mW
2N2060,A		0.5	0.6	
2N2223,A		0.5	0.6	
2N2480,A		0.3	0.6	
Derate above 25°C				mW/°C
2N2060,A		2.86	3.43	
2N2223,A		2.86	3.43	
2N2480,A		1.72	3.43	
Total Device Dissipation	P_D			
@ $T_C = 25°C$				Watts
2N2060,A		1.5	3.0	
2N2223,A		1.6	3.0	
2N2480,A		1.0	2.0	
Derate above 25°C				mW/°C
2N2060,A		8.6	17.2	
2N2223,A		9.1	11.4	
2N2480,A		5.7	11.4	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 100 mAdc, $R_{BE} \leq 10$ ohms)	2N2060, 2N2060A, 2N2223, 2N2223A	$V_{CER(sus)}$	80	—	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 20 mAdc, I_B = 0)	2N2480	$V_{CEO(sus)}$	40	—	Vdc
	2N2480A		40	—	
(I_C = 30 mAdc, I_B = 0)	2N2060, 2N2060A, 2N2223, 2N2223A		60	—	
				—	
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N2060, 2N2060A, 2N2223, 2N2223A	$V_{(BR)CBO}$	100	—	Vdc
	2N2480*		75	—	
	2N2480A*		80	—	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, i_C = 0)	2N2060, 2N2060A, 2N2223, 2N2223A	$V_{(BR)EBO}$	7.0	—	Vdc
	2N2480, 2N2480A		5.0	—	
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)	2N2480, 2N2480A	I_{CBO}	—	15	μAdc
(V_{CB} = 60 Vdc, I_E = 0)	2N2480		—	0.050	
	2N2480A		—	0.020	
(V_{CB} = 80 Vdc, I_E = 0)	2N2060, 2N2060A		—	0.002	
	2N2223, 2N2223A		—	0.010	
(V_{CB} = 80 Vdc, I_E = 0, T_A = 150°C)	2N2060, 2N2060A		—	10	
	2N2223, 2N2223A		—	15	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	2N2060, 2N2060A	I_{EBO}	—	2.0	nAdc
	2N2223, 2N2223A		—	10	
	2N2480		—	50	
	2N2480A		—	20	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	2N2060, 2N2060A		25	75	
	2N2223, 2N2223A		15	—	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N2060, 2N2060A		30	90	
	2N2223, 2N2223A		25	150	
	2N2480		20	—	
	2N2480A		35	—	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N2060, 2N2060A		40	120	
	2N2480 .		30	350	
	2N2480A		50	200	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	2N2060, 2N2060A		50	150	
	2N2223, 2N2223A		50	200	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)	2N2060A		—	0.6	
	2N2060, 2N2223, 2N2223A, 2N2480A		—	1.2	
	2N2480		—	1.3	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)	2N2060, 2N2060A,				
	2N2223, 2N2223A, 2N2480A		—	0.9	
	2N2480		—	1.0	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product		f_T			MHz
(I_C = 50 mAdc, V_{CE} = 10 Vdc,	2N2223, 2N2223A				
f = 20 MHz)	2N2480, 2N2480A		50	—	
	2N2060, 2N2060A		60	—	
Output Capacitance		C_{obo}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	2N2060, 2N2060A, 2N2223, 2N2223A		—	15	
	2N2480A		—	18	
	2N2480		—	20	
Input Capacitance		C_{ibo}	—	85	pF
(V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	2N2060, 2N2060A, 2N2223, 2N2223A, 2N2480A				
Input Impedance		h_{ie}			ohms
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc,	2N2060, 2N2060A		1000	4000	
f = 1.0 kHz)	2N2480A		1000	5000	
Input Impedance		h_{ib}			ohms
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc,	2N2060, 2N2060A, 2N2223,				
f = 1.0 kHz)	2N2223A		20	30	
	2N2480A		20	35	
Voltage Feedback Ratio		h_{rb}	—	3.0	X 10^{-4}
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	2N2223, 2N2223A				
Small-Signal Current Gain		h_{fe}			—
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc,	2N2060, 2N2060A		50	150	
f = 1.0 kHz)	2N2223, 2N2223A		40	200	
	2N2480A		50	300	
Output Admittance		h_{oe}	—	16	μmhos
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N2060, 2N2060A, 2N2480A				
Output Admittance		h_{ob}	—	0.5	μmhos
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	2N2223, 2N2223A				
Noise Figure		NF			dB
(I_C = 0.3 mAdc, V_{CE} = 10 Vdc, R_S = 510 Ω, f = 1.0 kHz, BW = 1.0 Hz)	2N2480, 2N2480A		—	8.0	
(I_C = 0.3 mAdc, V_{CE} = 10 Vdc,					

5

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
R_S = 510 Ω, f = 1.0 kHz, BW = 200 Hz)	2N2060, 2N2060A		—	8.0	
(I_C = 0.3 mAdc, V_{CE} = 10 Vdc, R_S = 1.0 kΩ, f = 1.0 kHz, BW = 15.7 kHz)(2)			—	8.0	

MATCHING CHARACTERISTICS

Characteristic		Symbol	Min	Max	Unit
DC Current Gain Ratio(3)		h_{FE1}/h_{FE2}			—
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N2060, 2N2060A, 2N2223A		0.9	1.0	
	2N2223, 2N2480, 2N2480A		0.8	1.0	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N2060, 2N2060A		0.9	1.0	
	2N2480, 2N2480		0.8	1.0	
Base-Emitter Voltage Differential		$\|V_{BE1}-V_{BE2}\|$			mVdc
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N2060A		—	3.0	
	2N2060, 2N2223A, 2N2480A		—	5.0	
	2N2480		—	10	
	2N2223		—	15	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N2060, 2N2060A, 2N2480A		—	5.0	
	2N2480		—	10	
Base-Emitter Voltage Differential Change Due to Temperature (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = −55°C to +125°C)		$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T}$			μV/°C
	2N2060A		—	5.0	
	2N2060		—	10	
	2N2223, 2N2223A		—	25	
	2N2480, 2N2480A		—	15	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) Amplifier: 3.0 Db points at 25 Hz and 10 kHz with a roll-off of 6.9 dB per octave.
(3) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

5

FIGURE 1 — DC CURRENT GAIN versus COLLECTOR CURRENT

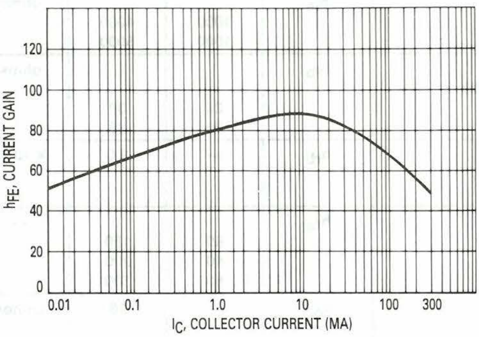
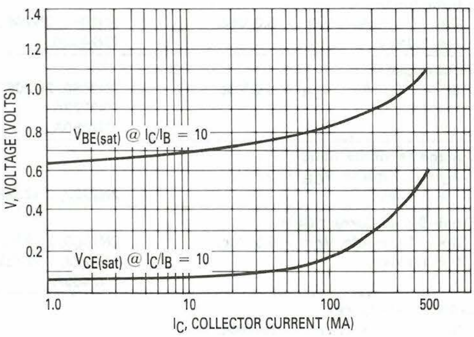
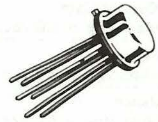


FIGURE 2 — "ON" VOLTAGES



2N2453,A

CASE 654-07, STYLE 1



DUAL AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N2920 for graphs.

MAXIMUM RATINGS

Rating	Symbol	2N2453	2N2453A	Unit
Collector-Emitter Voltage	V_{CEO}	30	50	Vdc
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Emitter-Base Voltage	V_{EBO}	7.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		One Die	**Both Die**	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	200 1.14	300 1.71	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	600 3.43	1200 6.86	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	 2N2453 2N2453A	$V_{CEO(sus)}$	 30 50	 — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	 2N2453 2N2453A	$V_{(BR)CBO}$	 60 80	 — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$) ($V_{CB} = 50$ Vdc, $I_E = 0$, $T_A = 150°C$)		I_{CBO}	 — —	 0.005 10	μAdc
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$)		I_{EBO}	—	0.002	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 10\ \mu$Adc, $V_{CE} = 5.0$ Vdc) ($I_C = 10\ \mu$Adc, $V_{CE} = 5.0$ Vdc, $T_A = -55°C$) ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, $T_A = -55°C$)		h_{FE}	 80 40 150 75	 — — 600 —	—
Collector-Emitter Saturation Voltage ($I_C = 5.0$ mAdc, $I_B = 0.5$ mAdc)		$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 5.0$ mAdc, $I_B = 0.5$ mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 30 MHz)		f_T	60	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 140 kHz)		C_{obo}	—	8.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 140 kHz)		C_{ibo}	—	10	pF
Input Impedance ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz)		h_{ie}	5.0	—	kohms
Input Impedance ($I_C = 1.0$ mAdc, $V_{CB} = 5.0$ Vdc, f = 1.0 kHz)		h_{ib}	20	30	Ohms

5

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{re}	—	6.0	X 10^{-4}
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{rb}	—	5.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	150	600	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{oe}	5.0	30	μmhos
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ob}	—	0.2	μmho
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ, f = 1.0 kHz)	NF	—	7.0	dB
MATCHING CHARACTERISTICS				
DC Current Gain Ratio(2) (I_C = 100 μAdc, V_{CE} = 5.0 Vdc) 2N2453A (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, T_A = −55°C to +125°C)	h_{FE1}/h_{FE2}	 0.90 0.90 0.85	 1.0 1.0 1.0	—
Base-Emitter Voltage Differential (I_C = 10 μAdc, V_{CE} = 5.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	$\lvert V_{BE1}-V_{BE2} \rvert$	 — —	 3.0 5.0	mVdc
Base-Emitter Voltage Differential Gradient (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = −55°C to +125°C) 2N2453 2N2453A	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	 — —	 10 5.0	μV/°C

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) Lowest h_{FE} reading is taken as h_{FE1} for this ratio.

5

2N2639 thru 2N2644

CASE 654-07, STYLE 1

DUAL AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N2913 for graphs.

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	45		Vdc
Collector-Base Voltage	V_{CBO}	45		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	30		mAdc
		One Die	Both Die	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 1.72	600 3.43	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	600 3.43	1200 6.87	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)		$V_{CEO(sus)}$	45	—	Vdc
Collector Cutoff Current ($V_{CE} = 5.0$ Vdc, $I_B = 0$)		I_{CEO}	—	0.010	μAdc
Collector Cutoff Current		I_{CBO}			μAdc
($V_{CB} = 45$ Vdc, $I_E = 0$)			—	0.010	
($V_{CB} = 45$ Vdc, $I_E = 0$, $T_A = +150°C$)			—	10	
Emitter Cutoff Current ($V_{EB} = 5.0$ Vdc, $I_C = 0$)		I_{EBO}	—	0.010	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain		h_{FE}			—
($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc)	2N2639, 2N2640, 2N2641		50	300	
	2N2642, 2N2643, 2N2644		100	300	
($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc, $T_A = -55°C$)	2N2639, 2N2640, 2N2641		10	—	
	2N2642, 2N2643, 2N2644		20	—	
($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc)	2N2639, 2N2640, 2N2641		55	—	
	2N2642, 2N2643, 2N2644		110	—	
($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)	2N2639, 2N2640, 2N2641		65	—	
	2N2642, 2N2643, 2N2644		130	—	
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 0.5$ mAdc)		$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 0.5$ mAdc)		$V_{BE(sat)}$	0.6	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 20 MHz)		f_T	40	—	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	8.0	pF
Input Impedance ($I_C = 1.0$ mAdc, $V_{CB} = 5.0$ Vdc, f = 1.0 kHz, $I_E = -1.0$ mA)		h_{ib}	25	32	ohms
Voltage Feedback Ratio ($I_C = 1.0$ mAdc, $V_{CB} = 5.0$ Vdc, f = 1.0 kHz, $I_E = -1.0$ mA)		h_{rb}	—	600	$X\ 10^{-6}$

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

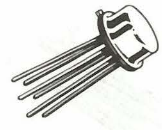
Characteristic		Symbol	Min	Max	Unit
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	2N2639, 2N2640, 2N2641	h_{fe}	65	600	—
	2N2642, 2N2643, 2N2644		130	600	
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz, I_E = −1.0 mA)		h_{ob}	—	1.0	μmhos
Noise Figure (I_C = 10 μAdc, V_{CB} = 5.0 Vdc, R_S = 10 kΩ, Bandwidth = 10 Hz to 15 kHz)		NF	—	4.0	dB
MATCHING CHARACTERISTICS					
DC Current Gain Ratio(2) (I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	2N2639, 2N2642	h_{FE1}/h_{FE2}	0.9	1.0	—
	2N2640, 2N2643		0.8	1.0	
Base-Emitter Voltage Differential (I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	2N2639, 2N2642	$\|V_{BE1}-V_{BE2}\|$	—	5.0	mVdc
	2N2640, 2N2643		—	10	
Base-Emitter Voltage Differential Gradient (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = −55 to +125°C)	2N2639, 2N2642	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	—	10	μV/°C
	2N2640, 2N2643		—	20	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) The lowest h_{FE} reading is taken as h_{FE1} for this test.

5

2N2652,A

CASE 654-07, STYLE 1



DUAL
AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N2060,A for graphs.

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	60		Vdc
Collector-Base Voltage	V_{CBO}	100		Vdc
Emitter-Base Voltage	V_{EBO}	7.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		One Die	Both Die	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.3 1.72	0.6 3.43	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.0 5.7	2.0 11.4	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

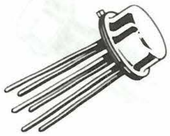
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 20$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	60	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	100	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$) ($V_{CB} = 50$ Vdc, $I_E = 0$, $T_A = 150°C$)	I_{CBO}	— —	0.010 15	μAdc
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$) 2N2652	I_{EBO}	—	0.010	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 100\ \mu$Adc, $V_{CE} = 5.0$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, $T_A = -55°C$)	h_{FE}	35 50 15	— 200 —	—
Collector-Emitter Saturation Voltage ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{CE(sat)}$	—	1.2	Vdc
Base-Emitter Saturation Voltage ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)	f_T	60	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	15	pF
Input Capacitance ($V_{BE} = 0$, 0.5 Vdc, $I_C = 0$, f = 1.0 MHz)	C_{ibo}	—	85	pF
Input Impedance ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz)	h_{ie}	1.0	10.5	kohms
Input Impedance ($I_C = 1.0$ mAdc, $V_{CB} = 5.0$ Vdc, f = 1.0 kHz)	h_{ib}	20	35	ohms
Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz)	h_{fe}	50	300	—
Output Admittance ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz)	h_{oe}	—	50	μmhos
Noise Figure ($I_C = 0.3$ mAdc, $V_{CE} = 10$ Vdc, $R_S = 610$ ohms, B. W. = 1.0 Hz, f = 1.0 kHz)	NF	—	8.0	dB
MATCHING CHARACTERISTICS				
DC Current Gain Ratio(2) ($I_C = 100\ \mu$Adc, $V_{CE} = 5.0$ Vdc) 2N2652 ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc) 2N2652	h_{FE1}/h_{FE2}	0.85 0.85	1.0 1.0	—
Base-Emitter Voltage Differential ($I_C = 100\ \mu$Adc, $V_{CE} = 5.0$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)	$\lvert V_{BE1}-V_{BE2}\rvert$	— —	3.0 3.0	mVdc
Base-Emitter Voltage Differential Gradient ($I_C = 100\ \mu$Adc, $V_{CE} = 5.0$ Vdc, $T_A = -55$ to $+125°C$)	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	—	10	μV/°C

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) The lowest of the two h_{FE} readings is taken as h_{FE1} for the purpose of measurement.

2N2720
2N2721

CASE 654-07, STYLE 1



DUAL AMPLIFIER TRANSISTOR

NPN SILICON

5

Refer to 2N2060 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	60		Vdc
Collector-Base Voltage	V_{CBO}	80		Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	40		mAdc
		One Die	**Both Die**	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.3 1.71	0.6 3.4	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.6 3.4	1.2 6.8	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	60	—	Vdc
Collector Cutoff Current (V_{CE} = 5.0 Vdc, I_B = 0)	I_{CEO}	—	10	nAdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	— —	0.01 10	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	10	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	30 35 42	120 — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	0.65	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	80	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	6.0	pF
Input Impedance (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ib}	25	32	ohms
Voltage Feedback Ratio (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{rb}	—	500	X 10^{-6}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	30	200	—
Output Admittance (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ob}	—	1.0	μmhos
MATCHING CHARACTERISTICS				
DC Current Gain Ratio(2) (I_C = 100 μAdc, V_{CE} = 5.0 Vdc) 2N2720 2N2721	h_{FE1}/h_{FE2}	 0.9 0.8	 1.0 1.0	—
Base-Emitter Voltage Differential (I_C = 100 μAdc, V_{CE} = 5.0 Vdc) 2N2720 2N2721	$\|V_{BE1}-V_{BE2}\|$	 — —	 5.0 10	mVdc
Base-Emitter Voltage Differential Change Due to Temperature (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = −55 to +25°C) 2N2720 2N2721 (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = +25 to +125°C) 2N2720 2N2721	$\Delta(V_{BE1}-V_{BE2})$	 — — — —	 0.8 1.6 1.0 2.0	mV

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) The lower of the two h_{FE} readings is taken as h_{FE1} for the purpose of measurement.

2N2722

CASE 654-07, STYLE 1

DUAL AMPLIFIER TRANSISTOR

NPN SILICON

5

Refer to 2N2920 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	45		Vdc
Collector-Base Voltage	V_{CBO}	45		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	40		mAdc
		One Die	Both Die	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.3 1.7	0.6 3.4	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	0.6 3.4	1.2 6.8	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

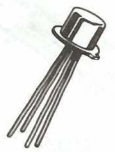
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	45	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	45	—	Vdc
Collector Cutoff Current ($V_{CE} = 5.0$ Vdc, $I_B = 0$)	I_{CEO}	—	2.0	nAdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$) ($V_{CB} = 30$ Vdc, $I_E = 0$, $T_A = 150°C$)	I_{CBO}	— —	0.001 1.0	μAdc
Emitter Cutoff Current ($V_{EB} = 5.0$ Vdc, $I_C = 0$)	I_{EBO}	—	1.0	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 1.0$ μAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 0.1$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	50 100 125	250 — —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 0.5$ mAdc)	$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 0.5$ mAdc)	$V_{BE(sat)}$	0.65	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz)	f_T	100	—	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	6.0	pF
Input Impedance ($I_E = 1.0$ mAdc, $V_{CB} = 5.0$ Vdc, f = 1.0 kHz)	h_{ib}	25	32	ohms
Voltage Feedback Ratio ($I_E = 1.0$ mAdc, $V_{CB} = 5.0$ Vdc, f = 1.0 kHz)	h_{rb}	—	600	$X\ 10^{-6}$
Small-Signal Current Gain ($I_E = 0.1$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz)	h_{fe}	100	700	—
Output Admittance ($I_E = 1.0$ mAdc, $V_{CB} = 5.0$ Vdc, f = 1.0 kHz)	h_{ob}	—	1.0	μmhos
Noise Figure ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ kΩ, f = 10 Hz to 15.7 kHz)	NF	—	4.0	dB
MATCHING CHARACTERISTICS				
DC Current Gain Ratio(2) ($I_C = 1.0$ μAdc, $V_{CE} = 5.0$ Vdc)	h_{FE1}/h_{FE2}	0.9	1.0	—
Base-Emitter Voltage Differential ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc)	$\vert V_{BE1}-V_{BE2}\vert$	—	5.0	mVdc
Base-Emitter Voltage Differential Change Due to Temperature ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc, $T_A = -55$ to $+25°C$) ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc, $T_A = +25$ to $+125°C$)	$\Delta(V_{BE1}-V_{BE2})$	 — —	 0.8 1.0	mVdc

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) The lower of the two h_{FE} readings is taken as h_{FE1} for the purpose of measurement.

2N2723

CASE 20-03, STYLE 8

TO-72 (TO-206AF)



DARLINGTON TRANSISTOR

NPN SILICON

5

Refer to 2N998 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage (Base 1 and Base 2 open)	V_{CE2O}	60	Vdc
Collector-Base Voltage	V_{CB1}	80	Vdc
Emitter-Base Voltage	V_{E2B1}	12	Vdc
Collector Current — Continuous	I_C	40	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.5 2.9	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.8 10.5	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_{B1} = 0$)	$V_{(BR)CE2O}$	60	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_{E2} = 0$)	$V_{(BR)CB1O}$	80	—	Vdc
Emitter-Base Breakdown Voltage ($I_{E2} = 10\ \mu$Adc, $I_C = 0$)	$V_{(BR)E2B1O}$	12	—	Vdc
Collector Cutoff Current ($V_{CB1} = 60$ Vdc, $I_E = 0$) ($V_{CB1} = 60$ Vdc, $I_E = 0$, $T_A = 150°C$)	I_{CB1O}	 — —	 0.01 10	μAdc
Emitter Cutoff Current ($V_{B1E2} = 10$ Vdc, $I_C = 0$)	I_{E2B1O}	—	10	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 10$ mAdc, $V_{CE2} = 5.0$ Vdc, $I_{B2} = 0$)	h_{FE}	2000	10,000	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_{B1} = 1.0$ mAdc)	$V_{CE2(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_{B1} = 1.0$ mAdc)	$V_{BE2(sat)}$	—	1.7	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB1} = 10$ Vdc, $I_{E2} = 0$, f = 140 kHz)	C_{ob1o}	—	10	pF
Small-Signal Current Gain ($I_C = 10$ mAdc, $V_{CE2} = 5.0$ Vdc, f = 1.0 kHz)	h_{fe}	1500	15,000	—
Current Gain — Bandwidth Product (Each Unit) ($I_C = 10$ mAdc, V_{CE1} or $V_{CE2} = 10$ Vdc, f = 20 MHz)	$\lvert h_{fe} \rvert$	5.0	—	—
Noise Figure (Input Stage Only) ($I_C = 50\ \mu$Adc, $V_{CE} = 5.0$ Vdc, $R_S = 3.0$ kohms, f = 1.0 kHz, BW = 100 Hz)	NF	—	10	dB

(1) Pulse Test: Pulse Width ≤ 12 ms, Duty Cycle ≤ 2.0%.

2N2785

CASE 22-03, STYLE 8
TO-72 (TO-206AF)

DARLINGTON TRANSISTOR

NPN SILICON

Refer to 2N998 for graphs.

5

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage (Base 1 and Base 2 open)	V_{CE2O}	40	Vdc
Collector-Base Voltage	V_{CB1O}	60	Vdc
Emitter-Base Voltage (Pin 4 to Pin 2)	V_{E2B1O}	15 7.5	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.5 2.9	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.8 10.5	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

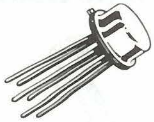
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 20$ mAdc, $I_{B1} = 0$)	$V_{(BR)CEO2O}$	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_{E2} = 0$)	$V_{(BR)CBO1O}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_{E2} = 100$ μAdc, $I_C = 0$)	$V_{(BR)E2BO1O}$	15	—	Vdc
Collector Cutoff Current ($V_{CE} = 20$ Vdc, $I_B = 0$)	I_{CEO}	—	500	nAdc
Collector Cutoff Current ($V_{CB1} = 30$ Vdc, $I_E = 0$) ($V_{CB1} = 30$ Vdc, $I_E = 0$, $T_A = 150°C$)	I_{CBO}	 — —	 0.05 10	μAdc
Emitter Cutoff Current ($V_{E2B1} = 5.0$ Vdc, $I_C = 0$)	I_{EBO}	—	20	nAdc
ON CHARACTERISTICS				
DC Current Gain(1) ($I_C = 1.0$ mAdc, $V_{CE2} = 4.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE2} = 5.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE2} = 5.0$ Vdc)	h_{FE}	 600 1200 2000	 — — 20,000	—
Collector-Emitter Saturation Voltage ($I_C = 15$ mAdc, $I_{B1} = 3.0$ mAdc)	$V_{CE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB1} = 10$ Vdc, $I_{E2} = 0$, f = 1.0 MHz)	C_{ob1o}	—	30	pF
Input Impedance ($I_C = 1.0$ mAdc, $V_{CB1} = 5.0$ Vdc, f = 1.0 kHz)	h_{ib}	30	80	Ohms
Voltage Feedback Ratio ($I_C = 1.0$ mAdc, $V_{CE2} = 5.0$ Vdc, f = 1.0 kHz)	h_{rb}	—	10	X 10^{-4}
Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE2} = 5.0$ Vdc, f = 1.0 kHz)	h_{fe}	600	—	—
Current Gain — High Frequency ($I_C = 1.0$ mAdc, $V_{CE2} = 5.0$ Vdc, f = 10 MHz)	$\|h_{fe}\|$	1.0	—	—
Output Admittance ($I_C = 1.0$ mAdc, $V_{CB1} = 5.0$ Vdc, f = 1.0 kHz)	h_{ob}	—	0.5	μmhos

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

5

2N2903

CASE 654-07, STYLE 1



DUAL
AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N2920 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	7.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		One Die	Both Die	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	200 1.14	300 1.71	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	0.6 3.43	1.2 6.86	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{CEO(sus)}$	30	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 μAdc, I_C = 0)	$V_{(BR)EBO}$	7.0	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	— —	0.01 15	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	0.01	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 μAdc, V_{CE} = 5.0 Vdc) (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = −55°C) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, T_A = −55°C)	h_{FE}	60 25 125 60	— — 625 —	—
Collector-Emitter Saturation Voltage (I_C = 5.0 mAdc, I_B = 0.5 mAdc)	$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 5.0 mAdc, I_B = 0.5 mAdc)	$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 30 MHz)	f_T	60	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{obo}	—	8.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ibo}	—	10	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{ie}	1.0	—	kohm
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ib}	20	30	ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{re}	—	6.0	$\times 10^{-4}$
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{rb}	—	5.0	$\times 10^{-4}$
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	150	600	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{oe}	5.0	30	μmhos
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ob}	—	0.2	μmho
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kohms, f = 1.0 kHz)	NF	—	7.0	dB
MATCHING CHARACTERISTICS				
DC Current Gain Ratio(2) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	h_{FE1}/h_{FE2}	0.8	1.0	—
Base-Emitter Voltage Differential (I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	$\lvert V_{BE1}-V_{BE2}\rvert$	—	10	mVdc
Base-Emitter Voltage Differential Gradient (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = −55°C to +125°C)	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	—	20	μV/°C

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) Lowest h_{FE} reading is taken as h_{FE1} for this ratio.

2N2913 thru 2N2920

JAN, JTX, JTXV, JANS AVAILABLE
CASE 654-07, STYLE 1

DUAL AMPLIFIER TRANSISTOR

NPN SILICON

5

MAXIMUM RATINGS

Rating	Symbol	2N2913 thru 2N2918	2N2919 2N2920	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	Vdc
Collector-Base Voltage	V_{CBO}	45	60	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	30		mAdc
		One Die	Both Die	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 1.7	500 2.86	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	750 4.3	1500 8.6	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)	2N2913 thru 18, 2N2919, 2N2920	$V_{(BR)CEO(sus)}$	45 60	— —	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	2N2913 thru 18, 2N2919, 2N2920	$V_{(BR)CBO}$	45 60	— —	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 5.0$ Vdc, $I_B = 0$)		I_{CEO}	—	—	0.002	μAdc
Collector Cutoff Current ($V_{CB} = 45$ Vdc, $I_E = 0$)	2N2913 thru 18, 2N2919, 2N2920	I_{CBO}	— —	— —	0.010 0.002	μAdc
($V_{CB} = 45$ Vdc, $I_E = 0$, $T_A = 150°C$)	All Types		—	—	10	
Emitter Cutoff Current ($V_{EB} = 5.0$ Vdc, $I_C = 0$)		I_{EBO}	—	—	0.002	μAdc
ON CHARACTERISTICS						
DC Current Gain(1) ($I_C = 10\ \mu$Adc, $V_{CE} = 5.0$ Vdc)	2N2913,15,17,19, 2N2914,16,18,20	h_{FE}	60 150	— —	240 600	—
($I_C = 10\ \mu$Adc, $V_{CE} = 5.0$ Vdc, $T_A = -55°C$)	2N2913,15,17,19, 2N2914,16,18, 2N2920		15 30 40	— — —	— — —	
($I_C = 100\ \mu$Adc, $V_{CE} = 5.0$ Vdc)	2N2913,15,17,19, 2N2914,16,18,20		100 225	— —	— —	
($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)	2N2913,15,17,19, 2N2914,16,18,20		150 300	— —	— —	
Collector-Emitter Saturation Voltage ($I_C = 1.0$ mAdc, $I_B = 0.1$ mAdc)		$V_{CE(sat)}$	—	—	0.35	Vdc
Base-Emitter On Voltage ($I_C = 100\ \mu$Adc, $V_{CE} = 5.0$ Vdc)		$V_{BE(on)}$	—	—	0.7	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product ($I_C = 500\ \mu$Adc, $V_{CE} = 5.0$ Vdc, f = 20 MHz)		f_T	60	—	—	MHz

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)		C_{obo}	—	4.0	6.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ib}	25	28	32	ohms
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ob}	—	—	1.0	μmhos
Noise Figure		NF				dB
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ, f = 1.0 kHz, BW = 200 Hz)	2N2914,16,18,20,		—	2.0	3.0	
	2N2913,15,17,19		—	3.0	4.0	
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ, f = 10 Hz to 15.7 kHz, BW = 10 kHz)	2N2914,16,18,20,		—	2.0	3.0	
	2N2913,15,17,19		—	3.0	4.0	
MATCHING CHARACTERISTICS						
DC Current Gain Ratio(2)		h_{FE1}/h_{FE2}				—
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N2917,18,		0.8	—	1.0	
	2N2915,16,19,20		0.9	—	1.0	
Base-Emitter Voltage Differential		$\|V_{BE1}-V_{BE2}\|$				mVdc
(I_C = 10 μAdc to 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N2917,18,		—	—	10	
	2N2915,16,19,20		—	—	5.0	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N2917,18,		—	—	5.0	
	2N2915,16,19,20		—	—	3.0	
Base-Emitter Voltage Differential Change Due to Temperature		$\Delta(V_{BE1}-V_{BE2})$				mVdc
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = −55°C to +25°C)	2N2917,18,		—	—	1.6	
	2N2915,16,19,20		—	—	0.8	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = +25°C to +125°C)	2N2917,18		—	—	2.0	
	2N2915,16,19,20		—	—	1.0	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

5

FIGURE 1 — DC CURRENT GAIN versus COLLECTOR CURRENT

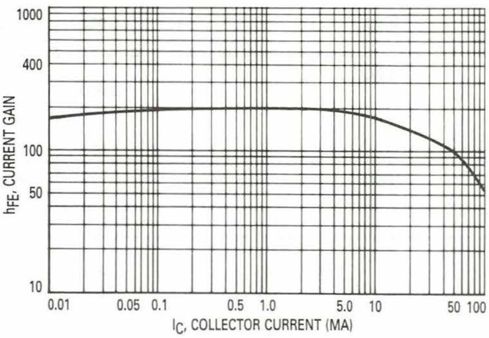


FIGURE 2 — DC CURRENT GAIN versus COLLECTOR CURRENT

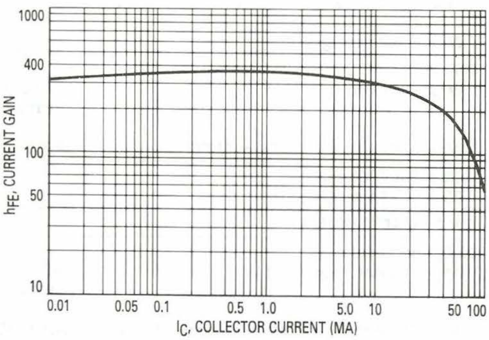


FIGURE 3 — "ON" VOLTAGES

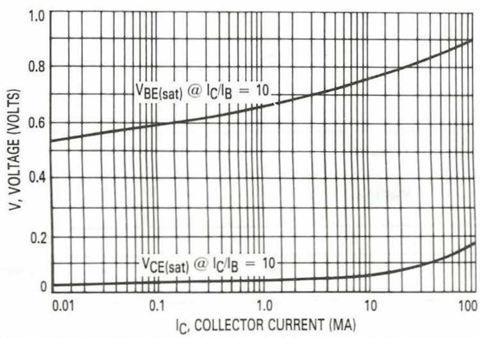
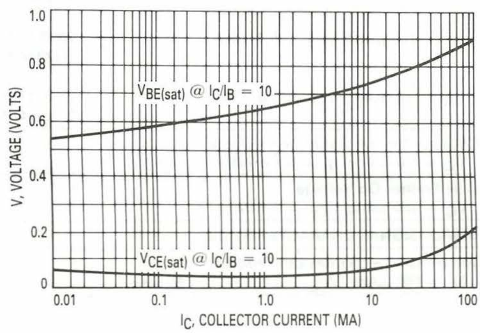
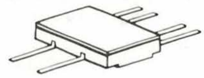


FIGURE 4 — "ON" VOLTAGES



2N3043 thru 2N3048

CASE 610A-04, STYLE 1



DUAL AMPLIFIER TRANSISTOR

NPN SILICON

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	45		Vdc
Collector-Base Voltage	V_{CBO}	45		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	30		mAdc
		One Die	Both Die	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	250 1.67	350 2.33	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	0.7 4.67	1.4 9.33	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	45	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 45$ Vdc, $I_E = 0$) ($V_{CB} = 45$ Vdc, $I_E = 0$, $T_A = +150°C$)		I_{CBO}	 — —	 0.010 10	μAdc
Emitter Cutoff Current ($V_{EB} = 4.0$ Vdc, $I_C = 0$)		I_{EBO}	—	0.010	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)	 2N3043, 2N3044, 2N3045 2N3046, 2N3047, 2N3048 2N3043, 2N3044, 2N3045 2N3046, 2N3047, 2N3048	h_{FE}	 100 50 130 65	 300 200 — —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 0.5$ mAdc)		$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter On Voltage ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)		V_{BE}	0.6	0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 20 MHz)		f_T	30	—	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	8.0	pF
Input Impedance ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz)	 2N3043, 2N3044, 2N3045 2N3046, 2N3047, 2N3048	h_{ie}	 3.2k 1.6k	 19k 13k	Ohms
Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz)	 2N3043, 2N3044, 2N3045 2N3046, 2N3047, 2N3048	h_{fe}	 130 65	 600 400	—
Output Admittance ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz)		h_{oe}	 — —	 100 70	μmhos
Noise Figure ($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ kohms, Bandwidth = 10 Hz to 15.7 kHz)		NF	—	5.0	dB

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
MATCHING CHARACTERISTICS					
DC Current Gain Ratio(2)		h_{FE1}/h_{FE2}			—
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	2N3043, 2N3046		0.9	1.0	
	2N3044, 2N3047		0.8	1.0	
Base-Emitter Voltage Differential		$\lvert V_{BE1} - V_{BE2} \rvert$			mVdc
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	2N3043, 2N3046		—	5.0	
	2N3044, 2N3047		—	10	
Base-Emitter Voltage Differential Temperature Gradient		$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$			μV/°C
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = −55 to +125°C)	2N3043, 2N3046		—	10	
	2N3044, 2N3047		—	20	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) The lowest h_{FE} reading is taken as h_{FE1} for this test.

5

2N3425

CASE 654-07, STYLE 1

DUAL
AMPLIFIER TRANSISTORS

NPN SILICON

Refer to MD2369,A,B for graphs.

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Emitter Voltage	V_{CER}	20		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
		One Die	Both Die	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.3 1.72	0.4 2.28	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	0.75 4.3	1.5 8.55	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

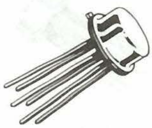
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 30$ mAdc, $R_{BE} \leq 10$ ohms)	$V_{CER(sus)}$	20	—	Vdc
Collector-Emitter Sustaining Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{CEO(sus)}$	15	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 20$ Vdc, $V_{EB(off)} = 0.25$ Vdc, $T_A = 125°C$)	I_{CEX}	—	15	μAdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$) ($V_{CB} = 20$ VDc, $I_E = 0$, $T_A = 150°C$)	I_{CBO}	— —	0.025 15	μAdc
Emitter Cutoff Current ($V_{EB} = 4.0$ Vdc, $I_C = 0$)	I_{EBO}	—	0.2	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 0.5$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc, $T_A = -55°C$)	h_{FE}	12 30 12	— 120 —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 7.0$ mAdc, $I_B = 0.7$ mAdc, $T_A = -55°C$ to $+125°C$)	$V_{CE(sat)}$	 — —	 0.4 0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 7.0$ mAdc, $I_B = 0.7$ mAdc, $T_A = -55°C$)	$V_{BE(sat)}$	0.7 —	0.85 0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 20$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	300	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 140 kHz)	C_{obo}	—	6.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 140 kHz)	C_{ibo}	—	9.0	pF
Small-Signal Current Gain ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc, f = 1.0 kHz)	h_{fe}	20	—	—
Real Part of Input Impedance ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 300 MHz)	$Re(h_{ie})$	—	50	Ohms
SWITCHING CHARACTERISTICS				
Storage Time ($I_C = 10$ mAdc, $I_{B1} = 10$ mAdc, $I_{B2} = 10$ mAdc)	t_s	—	40	ns
Turn-On Time ($V_{CC} = 3.0$ Vdc, $V_{EB(off)} = 2.0$ Vdc, $I_C = 10$ mAdc, $I_{B1} = 3.0$ mAdc)	t_{on}	—	50	ns
Turn-Off Time ($V_{CC} = 3.0$ Vdc, $I_C = 10$ mAdc, $I_{B1} = 3.0$ mAdc, $I_{B2} = 1.0$ mAdc)	t_{off}	—	90	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

2N3726
2N3727

CASE 654-07, STYLE 1



DUAL AMPLIFIER TRANSISTOR

PNP SILICON

Refer to MD2905,A for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	45		Vdc
Collector-Base Voltage	V_{CBO}	45		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Base Current	I_B	100		mAdc
Collector Current — Continuous	I_C	300		mAdc
		One Die	Both Die	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	400 2.29	500 2.86	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	0.85 4.85	1.4 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C
$Collector_1$ to $Collector_2$ Voltage Voltage rating any lead to case	V_{C1} V_{C2}	±200 ±200		Vdc Vdc

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	45	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.01$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	45	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.01$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$) ($V_{CB} = 30$ Vdc, $I_E = 0$, $T_A = 150°C$)	I_{CBO}	 — —	 10 10	 nAdc μAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 0.01$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 0.1$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 5.0$ Vdc)(1)	h_{FE}	 80 120 135 115	 — — 350 —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 50$ mAdc, $I_B = 2.5$ mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 50$ mAdc, $I_B = 2.5$ mAdc)	$V_{BE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(2) ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, f = 20 MHz) ($I_C = 50$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	 60 200	 — 600	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	8.0	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)	C_{ibo}	—	30	pF
Input Impedance ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{ie}	—	11.5	kohm
Voltage Feedback Ratio ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{re}	—	1500	$X\ 10^{-6}$
Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{fe}	135	420	—

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	—	80	μmhos
Noise Figure (I_C = 30 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kohms, f = 1.0 kHz, B.W. = 200 Hz)		NF	—	4.0	dB
MATCHING CHARACTERISTICS					
DC Current Gain Ratio(3) (I_C = 0.1 mAdc to 1.0 mAdc, V_{CE} = 5.0 Vdc)		h_{FE1}/h_{FE2}	0.9	1.0	—
Base-Emitter Voltage Differential (I_C = 0.1 mAdc to 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N3726	$\lvert V_{BE1}-V_{BE2}\rvert$	—	5.0	mVdc
	2N3727		—	2.5	
Base-Emitter Differential Change Due to Temperature (I_C = 0.1 mAdc to 1.0 mAdc, V_{CE} = 5.0 Vdc, T_A = −55°C to +25°C)	2N3726	$\Delta(V_{BE1}-V_{BE2})$	—	1.6	mVdc
	2N3727		—	0.8	
(I_C = 0.1 mAdc to 1.0 mAdc, V_{CE} = 5.0 Vdc, T_A = +25°C to +125°C)	2N3726		—	2.0	
	2N3727		—	1.0	

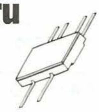
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.
(3) For purposes of this ratio, the lowest h_{FE} reading is taken as h_{FE1}.

5

2N3806 thru 2N3810,A 2N3811,A

CASE 654-07, STYLE 1

2N3812 thru 2N3816,A 2N3817,A



CASE 610A-04, STYLE 1

2N3810, 2N3811 — JAN, JTX, JTXV AVAILABLE

DUAL AMPLIFIER TRANSISTOR

PNP SILICON

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	60		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		One Die	**Both Die**	
Total Device Dissipation @ $T_A = 25°C$ Metal Can (2N3806 thru 2N3810,A, 2N3811,A)	P_D	500	600	mW
Derate above 25°C		2.86	3.43	mW/°C
Total Device Dissipation @ $T_C = 25°C$ Flat Package (2N3812 thru 2N3816,A, 2N3817,A)	P_D	250	350	mW
Derate above 25°C		1.5	2.06	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	60	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)		$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current		I_{CBO}			μAdc
($V_{CB} = 50$ Vdc, $I_E = 0$)			—	0.01	
($V_{CB} = 50$ Vdc, $I_E = 0$, $T_A = 150°C$)			—	10	
Emitter Cutoff Current ($V_{BE} = 4.0$ Vdc, $I_C = 0$)		I_{EBO}	—	20	nAdc
ON CHARACTERISTICS					
DC Current Gain(1)		h_{FE}			—
($I_C = 1.0$ μAdc, $V_{CE} = 5.0$ Vdc)	2N3807,9,11,A,13,15,17,A		75	—	
($I_C = 10$ μAdc, $V_{CE} = 5.0$ Vdc)	2N3806,8,10,A,12,14,16,A		100	—	
	2N3807,9,11,A,13,15,17,A		225	—	
($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc)	2N3806,8,10,A,12,14,16,A		150	450	
	2N3807,9,11,A,13,15,17,A		300	900	
($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc, $T_A = -55°C$)	2N3806,8,10,A,12,14,16,A		75	—	
	2N3807,9,11,A,13,15,17,A		150	—	
($I_C = 500$ μAdc, $V_{CE} = 5.0$ Vdc)	2N3806,8,10,A,12,14,16,A		150	450	
	2N3807,9,11,A,13,15,17,A		300	900	
($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)	2N3806,8,10,A,12,14,16,A		150	450	
	2N3807,9,11,A,13,15,17,A		300	900	
($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	2N3806,8,10,A,12,14,16,A		125	—	
	2N3807,9,11,A,13,15,17,A		250	—	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$			Vdc
($I_C = 100$ μAdc, $I_B = 1.0$ μA)	2N3814, 2N3815		—	0.2	
($I_C = 1.0$ mAdc, $I_B = 100$ μAdc)			—	0.25	
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$			Vdc
($I_C = 100$ μAdc, $I_B = 10$ μAdc)			—	0.7	
($I_C = 1.0$ mAdc, $I_B = 100$ μAdc)			—	0.8	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Base-Emitter On Voltage (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	—	0.7	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product		f_T			MHz
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 30 MHz)			30	—	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)			100	500	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	8.0	pF
Input Impedance		h_{ie}			Ω
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3806,8,10,A,12,14,16,A		3.0	30	
	2N3807,9,11,A,13,15,17,A		10	40	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{re}	—	25	X 10^{-4}
Small-Signal Current Gain		h_{fe}			—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3806,8,10,A,12,14,16,A		150	600	
	2N3807,9,11,A,13,15,17,A		300	900	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	5.0	60	μmhos
Noise Figure		NF			dB
(I_C = 100 μAdc, V_{CE} = 10 Vdc, R_G = 3.0 kohms					
f = 100 Hz, BW = 20 Hz	2N3806,8,10,A,12,14,16,A		—	7.0	
	2N3807,9,11,A,13,15,17,A		—	4.0	
Spot Noise f = 1.0 kHz, BW = 200 Hz	2N3806,8,10,A,12,14,16,A		—	3.0	
	2N3807,9,11,A,13,15,17,A		—	1.5	
f = 10 kHz, BW = 2.0 kHz)	2N3806,8,10,A,12,14,16,A		—	2.5	
	2N3807,9,11,A,13,15,17,A		—	1.5	
Broadband Noise Bandwidth	2N3806,8,10,A,12,14,16,A		—	3.5	
10 Hz to 15.7 kHz	2N3807,9,11,A,13,15,17,A		—	2.5	
MATCHING CHARACTERISTICS					
DC Current Gain Ratio(2)		h_{FE1}/h_{FE2}			—
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N3808,9,14,15		0.8	1.0	
	2N3810,11,16,17		0.9	1.0	
	2N3810A,11A,16A,17A		0.95	1.0	
(I_C = 100 μAdc, V_{CE} = 50 Vdc, T_A = −55 to +125°C)	2N3810A,11A,16A,17A		0.85	1.0	
Base-Emitter Voltage Differential		$\lvert V_{BE1}-V_{BE2}\rvert$			mVdc
(I_C = 10 μAdc to 10 mAdc, V_{CE} = 5.0 Vdc)	2N3808,9,14,15		—	8.0	
	2N3810,A,11,A,16,A,17,A		—	5.0	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N3808,9,14,15		—	5.0	
	2N3810,11,16,17		—	3.0	
	2N3810A,11A,16A,17A		—	1.5	
Base-Emitter Voltage Differential Change Due to Temperature		$\Delta(V_{BE1}-V_{BE2})$			mVdc
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = −55 to +25°C)	2N3808,9,14,15		—	1.6	
	2N3810,11,16,17		—	0.8	
	2N3810A,11A,16A,17A		—	0.4	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = +25 to +125°C)	2N3808,9,14,15		—	2.0	
	2N3810,11,16,17		—	1.0	
	2N3810A,11A,16A,17A		—	0.5	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

5

FIGURE 1 — DC CURRENT GAIN versus COLLECTOR CURRENT

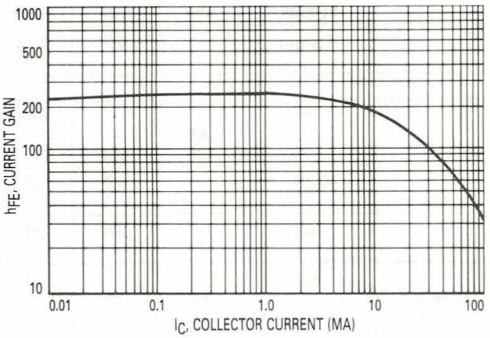


FIGURE 2 — DC CURRENT GAIN versus COLLECTOR CURRENT

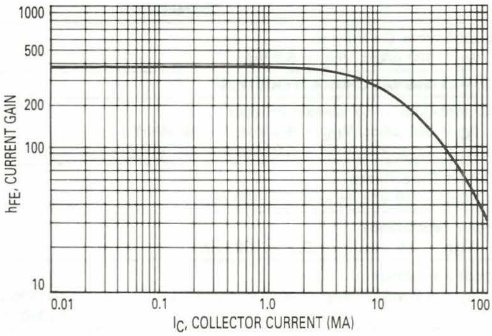


FIGURE 3 — "ON" VOLTAGES

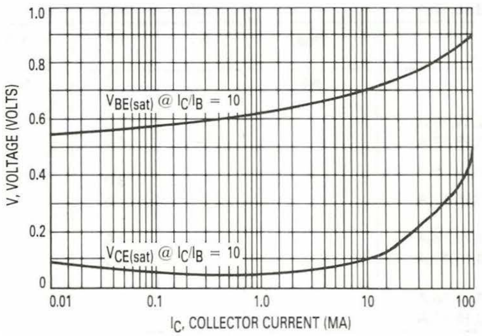
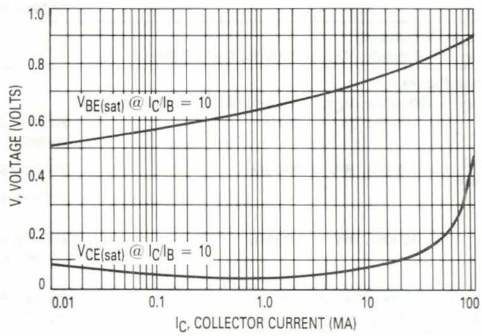
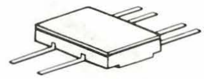


FIGURE 4 — "ON" VOLTAGES



2N3838

CASE 610A-04, STYLE 1



COMPLEMENTARY DUAL AMPLIFIER TRANSISTOR

NPN/PNP SILICON

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector 1 to Collector 2 Voltage Voltage Rating any Lead to Case	V_{C1C2}	±120 ±120		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
		One Die	**Both Die**	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.25 1.67	0.35 2.34	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.7 4.67	1.4 9.34	Watts
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Emitter Nonmatching Voltage ($I_{C(on)}$ = 600 mAdc, $I_{B(on)}$ = 120 mAdc, $I_{B(off)}$ = 0)	$V_{CEO(NL)}$†	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Base Cutoff Current (V_{CE} = 50 Vdc, $V_{BE(off)}$ = 0.5 Vdc)	I_{BEV}	—	10	nAdc
Collector Cutoff Current (V_{CE} = 50 Vdc, $V_{BE(off)}$ = 0.5 Vdc) (V_{CE} = 50 Vdc, $V_{BE(off)}$ = 0.5 Vdc, T_A = 150°C)	I_{CEV}	— —	0.01 10	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	10	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc)(1) (I_C = 150 mAdc, V_{CE} = 10 Vdc)(1) (I_C = 150 mAdc, V_{CE} = 1.0 Vdc)(1)	h_{FE}	35 50 75 100 50	— — — 300 —	—
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	0.85	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	200	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{obo}	—	8.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	1.6	9.0	kohms
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	60	300	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	—	50	μmho
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 kohm, f = 1.0 kHz)	NF	—	8.0	dB
SWITCHING CHARACTERISTICS				
Delay Time (V_{CC} = 10 Vdc, $V_{BE(off)}$ = 0 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_d	—	10	ns
Rise Time (V_{CC} = 10 Vdc, $V_{BE(off)}$ = 0 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_r	—	40	ns
Storage Time (V_{CC} = 10 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_s	—	250	ns
Fall Time (V_{CC} = 10 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_f	—	90	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

† The highest value of collector supply voltage that may be safely used with a resistive load switching circuit in which the collector current is 600 mAdc.

2N4015
2N4016

CASE 654-07, STYLE 1

DUAL AMPLIFIER TRANSISTOR

PNP SILICON

5

Refer to MD2905,A for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	60		Vdc
Collector 1 to Collector 2 Voltage Voltage Rating and Lead to Case	V_{C1C2}	±200 ±200		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Base Current	I_B	100		mAdc
Collector Current — Continuous	I_C	300		mAdc
		One Die	Both Die	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	400 2.29	500 2.86	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	0.85 4.85	1.4 8.0	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	60	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = +150°C)	I_{CBO}	 — —	 10 10	 nAdc μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.01 mAdc, V_{CE} = 5.0 Vdc) (I_C = 0.1 mAdc, V_{CE} = 5.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)(1)	h_{FE}	 80 120 135 115	 — — 350 —	—
Collector-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 2.5 mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 50 mAdc, V_{CE} = 2.5 Vdc)	$V_{BE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(2) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	 200 60	 600 —	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	8.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	25	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	—	11.5	kohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{re}	—	15	$X\ 10^{-4}$
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	135	420	—

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	—	80	μmhos
Noise Figure (I_C = 0.03 mAdc, V_{CE} = 5.0 Vdc, R_S = 10 kohms, f = 1.0 kHz, BW = 200 Hz)		NF	—	4.0	dB
MATCHING CHARACTERISTICS					
DC Current Gain Ratio (I_C = 0.1 mAdc, V_{CE} = 5.0 Vdc)		h_{FE1}/h_{FE2}	0.9	1.0	—
Base-Emitter Voltage Differential (I_C = 0.1 to 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N4015	$\lvert V_{BE1}-V_{BE2}\rvert$	—	5.0	mVdc
	2N4016		—	2.5	
Base-Emitter Voltage Differential Gradient (I_C = 0.1 to 1.0 mAdc, V_{CE} = 5.0 Vdc, T_A = −55 to +25°C)	2N4015	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	—	1.6	mVdc
	2N4016		—	0.8	
(I_C = 0.1 to 1.0 mAdc, V_{CE} = 5.0 Vdc, T_A = +25°C to +125°C)	2N4015		—	2.0	
	2N4016		—	1.0	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

2N4854
2N4855

2N4854 — JAN, JTX, JTXV AVAILABLE
CASE 654-07, STYLE 5

COMPLEMENTARY DUAL AMPLIFIER TRANSISTOR

NPN/PNP SILICON

5

Refer to MD6001 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector 1 to Collector 2 Voltage Voltage Rating any Lead to Case	V_{C1C2}	±200 ±200		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
		One Die	**Both Die**	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	600 4.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 6.67	2.0 13.33	Watts
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)		I_{CBO}	—	10	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	10	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N4854 2N4855		35 20	— —	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N4854 2N4855		50 25	— —	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)(1)	2N4854 2N4855		75 35	— —	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	2N4854 2N4855		100 40	300 120	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)(1)	2N4854 2N4855		50 20	— —	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)(1)	2N4854 2N4855		35 20	— —	
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$	0.75	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	200	—	MHz

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	—	8.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N4854 2N4855	h_{ie}	1.5 0.75	9.0 4.5	kohms
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N4854 2N4855	h_{fe}	60 30	300 150	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N4854 2N4855	h_{oe}	— —	50 25	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 kohm, f = 1.0 kHz)		NF	—	8.0	dB

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_d	—	20	ns
Rise Time		t_r	—	40	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_s	—	280	ns
Fall Time		t_f	—	70	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

5

2N4937
thru
2N4942

2N4937, 2N4938, 2N4939
CASE 654-07, STYLE 1

2N4440, 2N4441, 2N4442
CASE 610A-04, STYLE 1

DUAL
AMPLIFIER TRANSISTOR

PNP SILICON

Refer to MD3250,A for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector 1 to Collector 2 Voltage Voltage Rating and Lead to Case	V_{C1C2}	±200 ±200		Vdc
Collector-Base Voltage	V_{CBO}	50		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Base Current	I_B	10		mAdc
Collector Current — Continuous	I_C	50		mAdc
		One Die	**Both Die**	
Total Device Dissipation @ T_A = 25°C — Ceramic Metal Can Derate above 25°C — Ceramic Metal Can	P_D	 250 500 1.5 2.9	 350 600 2.0 3.4	 mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C Metal Can	P_D	 1.2 6.85	 2.0 11.42	 Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	50	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	—	20	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	20	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 100 μAdc, V_{CE} = 10 Vdc) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 40 50 50	 200 250 250	—
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 Mhz)	f_T	300	900	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz) Emitter Guarded	C_{cb}	—	5.0	pF
Input Impedance (I_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz) Collector Guarded	C_{eb}	—	10	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	1.0	10	kΩ
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{re}	—	10	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	50	—	—
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	5.0	50	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 kΩ, f = 10 Hz to 15.7 kHz)	NF	—	4.0	dB

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
MATCHING CHARACTERISTICS					
DC Current Gain Ratio(1)		h_{FE1}/h_{FE2}			—
(I_C = 100 μAdc to 1.0 mAdc, V_{CE} = 10 Vdc)	2N4937, 2N4941		0.9	1.0	
	2N4938, 2N4940		0.8	1.0	
(I_C = 100 μAdc to 1.0 mAdc, V_{CE} = 10 Vdc,					
T_A = −55°C to 125°C)	2N4937, 2N4941		0.85	1.0	
	2N4938, 2N4940		0.7	1.0	
Base-Emitter Voltage Differential		$\lvert V_{BE1}-V_{BE2}\rvert$			mVdc
(I_C = 100 μAdc to 1.0 mAdc, V_{CE} = 10 Vdc)	2N4937, 2N4941		—	3.0	
	2N4938, 2N4940		—	5.0	
Base-Emitter Voltage Differential Gradient		$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$			mVdc
(I_C = 100 μAdc to 1.0 mAdc, V_{CE} = 10 Vdc,				1.0	
T_A = 25°C to +125°C)	2N4937, 2N4941		—	2.0	
	2N4938, 2N4940		—		
(I_C = 100 μAdc to 1.0 mAdc, V_{CE} = 10 Vdc,				0.8	
T_A = −55°C to 25°C)	2N4937, 2N4941		—	1.6	
	2N4938, 2N4940		—		

(1) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

5

2N5793
2N5794

JAN, JTX, JTXV AVAILABLE
CASE 654-07, STYLE 1

DUAL TRANSISTOR

NPN SILICON

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	75		Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
		One Die	Both Die Equal Power	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 2.9	600 3.4	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.9	2.0 11.43	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

Refer to MD2218,A for graphs.

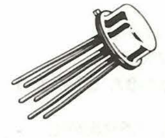
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	75	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	—	10	nAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	10	nAdc
Collector 1 to Collector 2 Leakage Current (V_{1C-2C} = ± 50 Vdc)	I_{C1-C2}	—	±1.0	nAdc
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			—
(I_C = 100 μAdc, V_{CE} = 10 Vdc) 2N5793		20	—	
2N5794		35	—	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc) 2N5793		25	—	
2N5794		50	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)(1) 2N5793		35	—	
2N5794		75	—	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)(1) 2N5793		20	—	
2N5794		50	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1) 2N5793		40	120	
2N5794		100	300	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)(1) 2N5793		25	—	
2N5794		40	—	
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc)	$V_{CE(sat)}$	— —	0.3 0.9	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc)	$V_{BE(sat)}$	0.6 —	1.2 1.8	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(2) (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	250	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	—	8.0	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{eb}	—	25	pF
SWITCHING CHARACTERISTICS				
Delay Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_d	—	15	ns
Rise Time	t_r	—	30	ns
Storage Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_s	—	250	ns
Fall Time	t_f	—	60	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

2N5795
2N5796

JAN, JTX, JTXV AVAILABLE
CASE 654-07, STYLE 1



DUAL TRANSISTOR

PNP SILICON

5

Refer to MD2904,A for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	60		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
		One Die	Both Die Equal Power	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	500 2.9	600 3.4	mW mW/°C
Total Power Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.2 6.9	2.0 11.43	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	60	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)		$V_{(BR)CBO}$	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$)		I_{CBO}	—	20	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	100	nAdc
Collector 1 to Collector 2 Leakage Current ($V_{1C-2C} = \pm 50$ Vdc		I_{C1-C2}	—	±1.0	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
($I_C = 100$ μAdc, $V_{CE} = 10$ Vdc)	2N5795		40	—	
	2N5796		75	—	
($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc)	2N5795		40	—	
	2N5796		100	—	
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)(1)	2N5795		40	—	
	2N5796		100	—	
($I_C = 150$ mAdc, $V_{CE} = 1.0$ Vdc)(1)	2N5795		20	—	
	2N5796		50	—	
($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)(1)	2N5795		40	120	
	2N5796		100	300	
($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc)(1)	2N5795		40	—	
	2N5796		50	—	
Collector-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)		$V_{CE(sat)}$	— —	0.4 1.6	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 150$ mAdc, $I_B = 15$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)		$V_{BE(sat)}$	— —	1.3 2.6	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 50$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)		f_T	200	—	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)		C_{cb}	—	8.0	pF
Emitter-Base Capacitance ($V_{EB} = 2.0$ Vdc, $I_C = 0$, f = 100 kHz)		C_{eb}	—	30	pF
SWITCHING CHARACTERISTICS (See Figure 1)					
Delay Time	($V_{CC} = 30$ Vdc, $V_{BE(off)} = 0.5$ Vdc, $I_C = 150$ mAdc, $I_{B1} = 15$ mAdc)	t_d	—	12	ns
Rise Time		t_r	—	35	ns
Storage Time	($V_{CC} = 30$ Vdc, $I_C = 150$ mAdc, $I_{B1} = I_{B2} = 15$ mAdc)	t_s	—	100	ns
Fall Time		t_f	—	40	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

2N6501
2N6502
2N6503

QUAD CERAMIC
2N6501
CASE 607,04, STYLE 1

DUAL
2N6502
CASE 654-07, STYLE 1

DUAL CERAMIC
2N6503
CASE 610A-04, STYLE 1

SWITCHING TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CES}	80		Vdc
Collector-Base Voltage	V_{CBO}	80		Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
		One Die	**All Die Equal Power**	
Total Device Dissipation @ $T_A = 25°C$	P_D			mW
2N6502		600	650	
2N6503		350	400	
2N6501		400	600	
Derate above 25°C				mW/°C
2N6502		3.42	3.7	
2N6503		2.0	2.28	
2N6501		2.28	3.42	
Total Device Dissipation @ $T_C = 25°C$	P_D			Watts
2N6502		2.1	3.0	
2N6503		1.25	2.5	
2N6501		1.0	4.0	
Derate above 25°C				mW/°C
2N6502		12	17.2	
2N6503		7.15	14.3	
2N6501		5.71	22.8	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
2N6502		83.3	58.3	
2N6503		140	70	
2N6501		175	43.8	
Thermal Resistance, Junction to Ambient(1)	$R_{\theta JA}$			°C/W
2N6502		292	270	
2N6503		500	438	
2N6501		438	292	
		Junction to Ambient	**Junction to Case**	
Coupling Factor				
2N6502		85	40	
2N6503		75	0	
2N6501 (Q1, Q2)		57	0	
(Q1-Q3, Q1-Q4)		56	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100$ μAdc, $V_{BE} = 0$)	$V_{(BR)CES}$	80	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	80	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	6.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 40$ Vdc, $I_E = 0$)	I_{CBO}	—	1.7	μAdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			—
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		50	150	
(I_C = 500 mAdc, V_{CE} = 2.0 Vdc)		30	—	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)		10	—	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)		—	0.3	
(I_C = 500 mAdc, I_B = 50 mAdc)		—	0.5	
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	0.8	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	250	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	—	10	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{eb}	—	65	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 30 Vdc, V_{BE} = 3.8 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc)	t_{on}	—	35	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_{off}	—	60	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

5

TYPICAL DC CHARACTERISTICS

FIGURE 1 — DC CURRENT GAIN

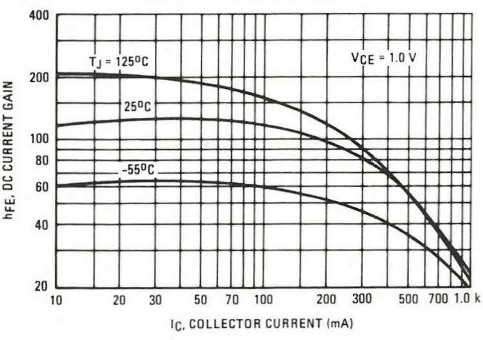


FIGURE 2 — "ON" VOLTAGES

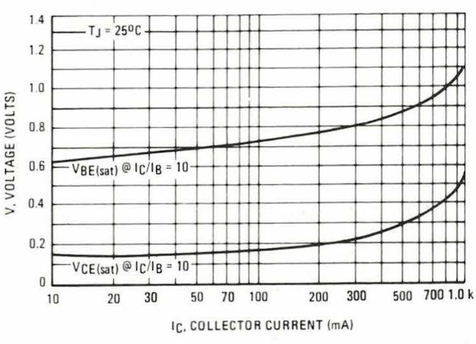


FIGURE 3 – COLLECTOR SATURATION REGION

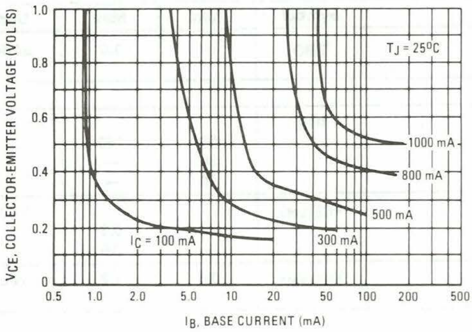
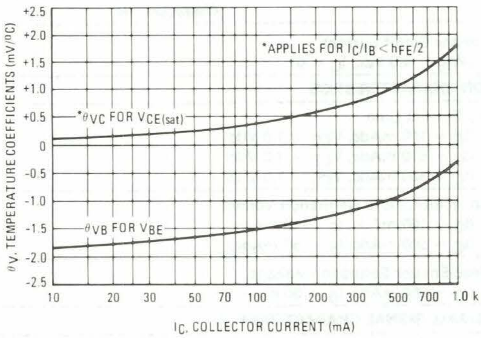


FIGURE 4 – TEMPERATURE COEFFICIENTS



5

TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 5 – CURRENT-GAIN – BANDWIDTH PRODUCT

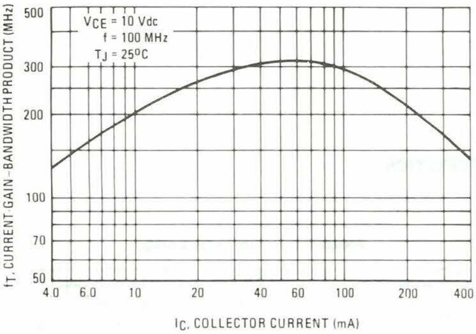


FIGURE 6 – CAPACITANCE

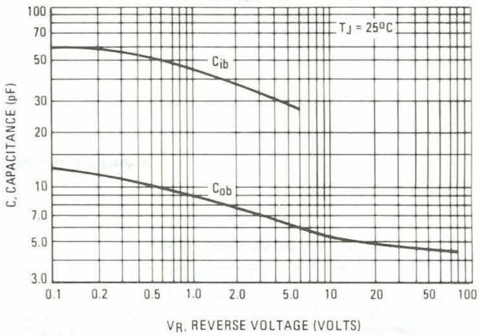


FIGURE 7 – TURN-ON TIME

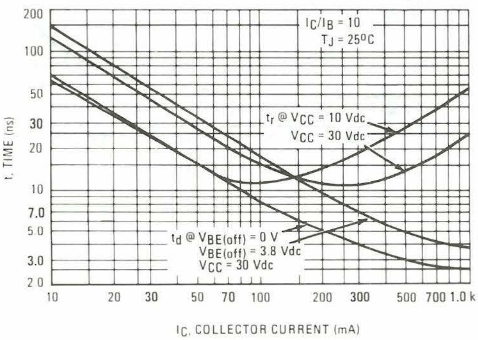


FIGURE 8 – TURN-OFF TIME

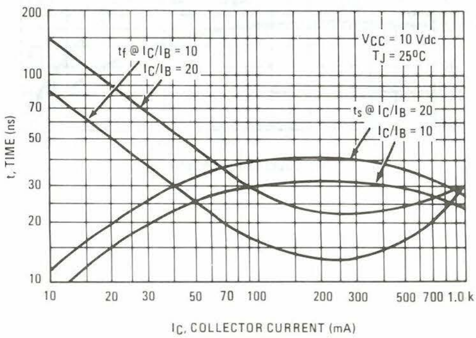


FIGURE 9 — SWITCHING TIME TEST CIRCUIT

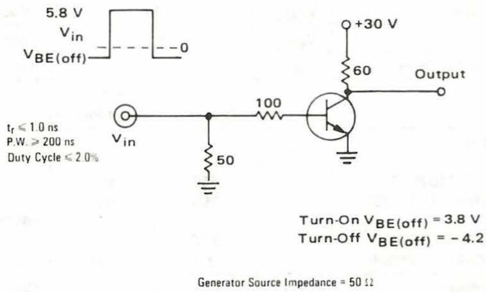
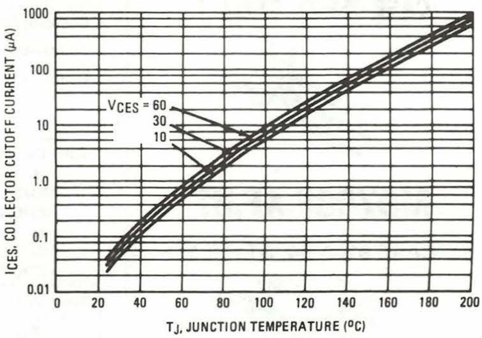


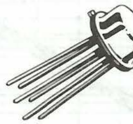
FIGURE 10 — COLLECTOR CUTOFF CURRENT



5

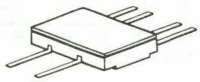
MD708,A,B

CASE 654-07, STYLE 1



MD708F,AF,BF

CASE 610A-04, STYLE 1



DUAL AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MD2369 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
		One Die	**Both Die Equal Power**	
Total Device Dissipation @ $T_A = 25°C$	P_D			mW
MD708, MD708A, MD708B		550	600	
MD708F, MD708AF, MD708BF		350	400	
Derate above 25°C				mW/°C
MD708, MD708A, MD708B		3.13	3.42	
MD708F, MD708AF, MD708BF		2.0	2.28	
Total Device Dissipation @ $T_C = 25°C$	P_D			Watts
MD708, MD708A, MD708B		1.4	2.0	
MD708F, MD708AF, MD708BF		0.7	1.4	
Derate above 25°C				mW/°C
MD708, MD708A, MD708B		8.0	11.4	
MD708F, MD708AF, MD708BF		4.0	8.0	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	Both Die Equal Power	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD708, MD708A, MD708B		125	87.5	
MD708F, MD708AF, MD708BF		250	125	
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	319	292	°C/W
		500	438	
		Junction to Ambient	**Junction to Case**	
Coupling Factors				%
MD708, MD708A, MD708B		83	40	
MD708F, MD708AF, MD708BF		75	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(2) ($I_C = 30$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	15	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)	I_{CBO}	—	15	nAdc
($V_{CB} = 20$ Vdc, $I_E = 0$, $T_A = 150°C$)		—	30	μAdc
ON CHARACTERISTICS				
DC Current Gain(2) ($I_C = 500$ μAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	40	—	—
($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)		40	200	
($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)		35	—	
($I_C = 150$ mAdc, $V_{CE} = 5.0$ Vdc)		20	—	
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	0.20	Vdc
($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		—	0.35	
($I_C = 100$ mAdc, $I_B = 10$ mAdc)		—	0.50	
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	0.65	0.85	Vdc
($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		—	0.95	
($I_C = 100$ mAdc, $I_B = 10$ mAdc)		—	1.10	

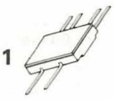
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MD918
MD918A
MD918B

CASE 654-07, STYLE 1

MD918F
MD918AF
MD918BF

CASE 610A-04, STYLE 1



DUAL
AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CBO}	30		Vdc
Emitter-Base Voltage	V_{EBO}	3.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		One Die	**Both Die**	
Total Device Dissipation @ $T_A = 25°C$	P_D			
MD918,A,B		550	600	mW
MD918F,AF,BF		350	400	
Derate above 25°C				
MD918,A,B		3.14	3.42	mW/°C
MD918F,AF,BF		2.0	2.28	
Total Device Dissipation @ $T_C = 25°C$	P_D			
MD918,A,B		1.4	2.0	Watts
MD918F,AF,BF		0.7	1.4	
Derate above 25°C				
MD918,A,B		8.0	11.4	mW/°C
MD918F,AF,BF		4.0	8.0	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic		Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case		$R_{\theta JC}$			°C/W
	MD918,A,B		125	87.5	
	MD918F,AF,BF		250	125	
Thermal Resistance, Junction to Ambient		$R_{\theta JA}$(1)			°C/W
	MD918,A,B		319	292	
	MD918F,AF,BF		500	438	
			Junction to Ambient	**Junction to Case**	
Coupling Factors					%
	MD918,A,B		83	40	
	MD918F,AF,BF		75	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 3.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 1.0$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current	I_{CBO}				
($V_{CB} = 15$ Vdc, $I_E = 0$)		—	—	10	nAdc
($V_{CB} = 15$ Vdc, $I_E = 0$, $T_A = 150°C$)		—	—	1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 3.0$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	50	165	—	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ Adc)	$V_{CE(sat)}$	—	0.09	0.2	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	—	0.86	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	600	—	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	1.1	1.7	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	1.15	2.0	pF
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, R_S = 400Ω, f = 60 MHz)		NF	—	—	6.0	dB
MATCHING CHARACTERISTICS						
DC Current Gain Ratio(3) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	 MD918B,BF MD918A,AF	h_{FE1}/h_{FE2}	 0.8 0.9	 — —	 1.0 1.0	—
Base-Emitter Voltage Differential (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	 MD918B,BF MD918A,AF	$\lvert V_{BE1}-V_{BE2}\rvert$	 — —	 — —	 10 5.0	mVdc
Base-Emitter Voltage Differential Gradient (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, T_A = −55 to +125°C)	 MD918B,AF,BF MD918A	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	 — —	 — —	 20 10	 µV/dc °C

(2) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.
(3) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

5

FIGURE 1 — DC CURRENT GAIN

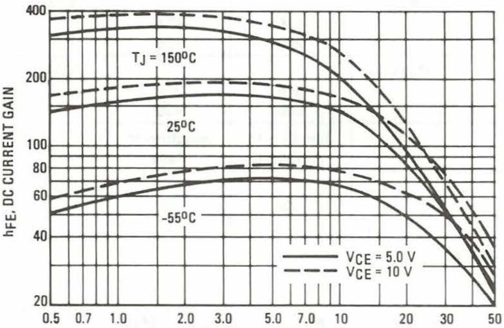


FIGURE 2 — "ON" VOLTAGES

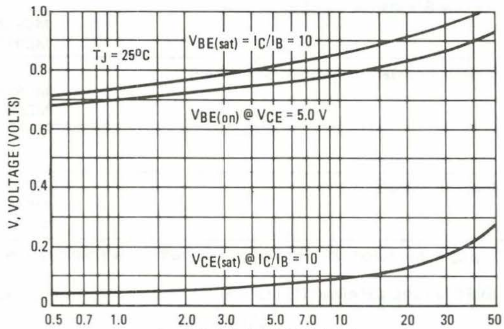


FIGURE 3 — BASE-EMITTER TEMPERATURE COEFFICIENT

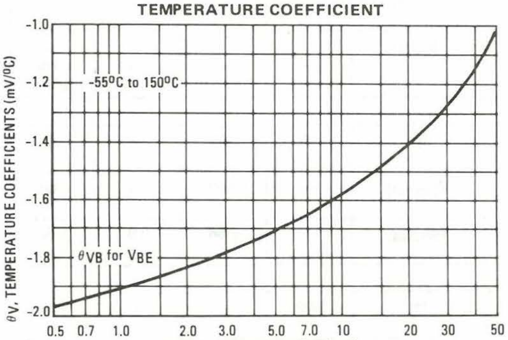


FIGURE 4 — CURRENT-GAIN BANDWIDTH PRODUCT

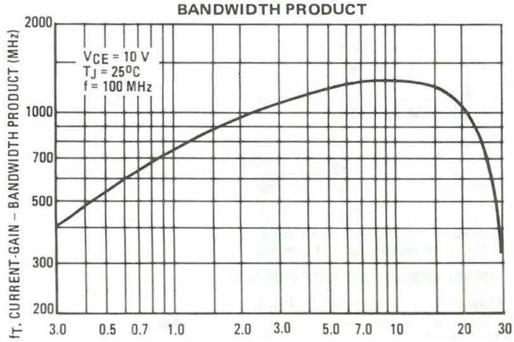
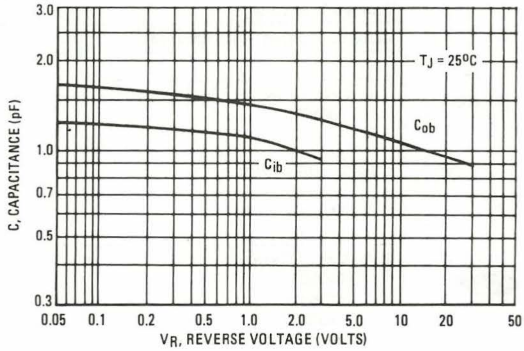


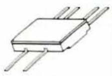
FIGURE 5 – CAPACITANCE



MD982,F
MQ982

MD982
CASE 654-07, STYLE 1

MD982F
CASE 610A-04, STYLE 1



MQ982
CASE 607-04, STYLE 1

DUAL
AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	50		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
		One Die	All Die	
Total Device Dissipation @ T_A = 25°C	P_D			mW
MD982		600	650	
MD982F		350	400	
MQ982		400	600	
Derate above 25°C				mW/°C
MD982		3.42	3.7	
MD982F		2.0	2.28	
MQ982		2.28	3.42	
Total Device Dissipation @ T_C = 25°C	P_D			Watts
MD982		2.1	3.8	
MD982F		1.25	2.5	
MQ982		1.0	4.0	
Derate above 25°C				mW/°C
MD982		12	17.2	
MD982F		7.15	14.3	
MQ982		5.71	22.8	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic		Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case		$R_{\theta JC}$			°C/W
	MD982		83.3	58.3	
	MD982F		140	70	
	MQ982		175	43.8	
Thermal Resistance, Junction to Ambient		$R_{\theta JA}$(1)			°C/W
	MD982		292	270	
	MD982F		500	438	
	MQ982		438	292	
			Junction to Ambient	Junction to Case	
Coupling Factor					%
	MD982		85	40	
	MD982F		75	0	
	MQ982 (Q1-Q2)		57	0	
	(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	50	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	—	—	0.020	μAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)		—	—	20	
ON CHARACTERISTICS(2)					
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	50	—	—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		25	75	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		35	90	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)		40	60	—	
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	—	0.25	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	—	0.88	1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	320	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	5.8	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	16	30	pF

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	20		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
		One Die	Both Die Equal Power	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	575 3.29	625 3.57	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10.3	2.5 14.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

MD984

CASE 654-07, STYLE 1

DUAL AMPLIFIER TRANSISTOR

PNP SILICON

Refer to MD3250 for graphs.

5

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	Both Die Equal Power	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	70	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	304	280	°C/W
		Junction to Ambient	Junction to Case	
Coupling Factor		84	44	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

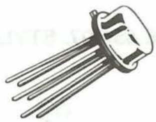
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 — —	 — —	 25 30	 nAdc μAdc
ON CHARACTERISTICS					
DC Current Gain(2) (I_C = 10 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	75	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)(2)	$V_{CE(sat)}$	 — —	 0.18 0.38	 0.3 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	0.8	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	250	550	—	MHz

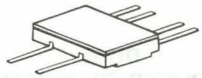
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MD985,F

MD985
CASE 654-07, STYLE 5



MD985F
CASE 610A-04, STYLE 1



COMPLEMENTARY DUAL GENERAL PURPOSE TRANSISTOR

NPN/PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		One Die	Both Die Equal Power	
Total Device Dissipation @ T_A = 25°C	P_D			mW
MD985		575	625	
MD985F		350	400	
Derate above 25°C				mW/°C
MD985		3.29	3.57	
MD985F		2.0	2.28	
Total Device Dissipation @ T_C = 25°C	P_D			Watts
MD985		1.8	2.5	
MD985F		1.0	2.0	
Derate above 25°C				mW/°C
MD985		10.3	14.3	
MD985F		5.71	11.4	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	Both Die Equal Power	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD985		97	70	
MD985F		175	87.5	
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)			°C/W
MD985		304	280	
MD985F		500	438	
		Junction to Ambient	Junction to Case	
Coupling Factor				%
MD985		84	44	
MD985F		75	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current	I_{CBO}				
(V_{CB} = 50 Vdc, I_E = 0)		—	—	20	nAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = +150°C)		—	—	20	μAdc
ON CHARACTERISTICS					
DC Current Gain	h_{FE}				—
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)		20	50	—	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		25	75	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		35	90	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)		40	90	—	
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	—	0.3	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	—	1.0	1.4	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz) MD985	f_T	200	320	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	5.8	8.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	20	—	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_{on}	—	25	—	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_{off}	—	75	—	ns

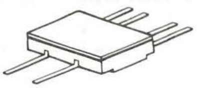
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

5

MD986,F

MD986
CASE 654-07, STYLE 5

MD986F
CASE 610A-04, STYLE 1



COMPLEMENTARY DUAL GENERAL PURPOSE TRANSISTOR

NPN/PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
		One Die	Both Die Equal Power	
Total Device Dissipation @ T_A = 25°C	P_D			mW
MD986		550	600	
MD986F		350	400	
Derate above 25°C				mW/°C
MD986		3.14	3.42	
MD986F		2.0	2.28	
Total Device Dissipation @ T_C = 25°C	P_D			Watts
MD986		1.4	2.0	
MD986F		0.7	1.4	
Derate above 25°C				mW/°C
MD986		8.0	11.4	
MD986F		4.0	8.0	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic		Symbol	One Die	Both Die Equal Power	Unit
Thermal Resistance, Junction to Case		$R_{\theta JC}$			°C/W
	MD986		125	87.5	
	MD986F		250	125	
Thermal Resistance, Junction to Ambient		$R_{\theta JA}$(1)			°C/W
	MD986		319	292	
	MD986F		500	438	
			Junction to Ambient	Junction to Case	
Coupling Factors					%
	MD986		83	40	
	MD986F		75	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	—	25	nAdc
(V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)		—	—	30	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	—	—	—
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		—	—	0.3	
(I_C = 50 mAdc, I_B = 10 mAdc)		—	—	0.5	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product	f_T				MHz
(I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		200	320	—	
(I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz) MD986F		200	320	—	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	—	4.0	pF

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

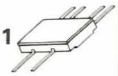
MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		One Die	All Die Equal Power	
Total Device Dissipation @ $T_A = 25°C$	P_D			
MD1120, MD1121, MD1122		575	625	mW
MD1120F, MD1121F, MD1122F		350	400	
MQ1120		400	600	
Derate above 25°C				
MD1120, MD1121, MD1122		3.29	3.57	mW/°C
MD1120F, MD1121F, MD1122F		2.0	2.28	
MQ1120		2.28	3.42	
Total Device Dissipation @ $T_C = 25°C$	P_D			
MD1120, MD1121, MD1122		1.8	2.5	Watts
MD1120F, MD1121F, MD1122F		1.0	2.0	
MQ1120		0.9	3.6	
Derate above 25°C				
MD1120, MD1121, MD1122		10.3	14.3	mW/°C
MD1120F, MD1121F, MD1122F		5.71	11.4	
MQ1120		5.13	20.5	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

MD1120,F
MD1121,F
MD1122,F
MQ1120

MD1120, MD1121, MD1122
CASE 654-07, STYLE 1

MD1120F
CASE 610A-04, STYLE 1



MQ1120
CASE 607-04, STYLE 1

DUAL
AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MD2218,A for graphs.

5

THERMAL CHARACTERISTICS

Characteristic		Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case		$R_{\theta JC}$			°C/W
	MD1120, MD1121, MD1122		97	70	
	MD1120F, MD1121F, MD1122F		175	87.5	
	MQ1120		195	48.8	
Thermal Resistance, Junction to Ambient		$R_{\theta JA}$(1)			°C/W
	MD1120, MD1121, MD1122		304	280	
	MD1120F, MD1121F, MD1122F		500	438	
	MQ1120		438	292	
			Junction to Ambient	Junction to Case	Unit
Coupling Factors					%
	MD1120, MD1121, MD1122		84	44	
	MD1120F, MD1121F, MD1122F		75	0	
	MQ1120 (Q1-Q2)		57	0	
	(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current	I_{CBO}				
($V_{CB} = 50$ Vdc, $I_E = 0$)		—	—	10	nAdc
($V_{CB} = 50$ Vdc, $I_E = 0$, $T_A = 150°C$)		—	—	10	μAdc
Emitter Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	10	nAdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain(2)	h_{FE}				—
(I_C = 10 μAdc, V_{CE} = 10 Vdc)		20	40	100	
(I_C = 100 μAdc, V_{CE} = 10 Vdc)		30	50	120	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		40	60	160	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		50	65	200	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	80	100	mVdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	700	850	mVdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	250	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	3.5	8.0	pF
MATCHING CHARACTERISTICS					
DC Current Gain Ratio(3)	h_{FE1}/h_{FE2}				—
(I_C = 100 μAdc, V_{CE} = 10 Vdc) All Devices		0.8	—	1.0	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc) MD1122, MD1122F		0.9	—	1.0	
Base-Emitter Voltage Differential	$\lvert V_{BE1}-V_{BE2}\rvert$				mVdc
(I_C = 100 μAdc, V_{CE} = 10 Vdc) All Devices		—	—	10	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc) MD1122, MD1122F		—	—	5.0	
Base-Emitter Voltage Differential Change Due to Temperature — MD1121, MD1122	$\Delta(V_{BE1}-V_{BE2})$				mVdc
(I_C = 100 μAdc, V_{CE} = 10 Vdc, T_A = −55 to +25°C)		—	—	0.8	
(I_C = 100 μAdc, V_{CE} = 10 Vdc, T_A = +25 to +125°C)		—	—	1.0	

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(3) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

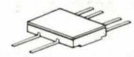
MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
		One Die	All Die	
Total Device Dissipation @ $T_A = 25°C$	P_D			mW
MD1123, MD1130		575	625	
MD1130F		350	400	
Derate above 25°C				mW/°C
MD1123, MD1130		3.29	3.57	
MD1130F		2.0	2.28	
Total Device Dissipation @ $T_C = 25°C$	P_D			Watts
MD1123, MD1130		1.8	2.5	
MD1130F		1.0	2.0	
Derate above 25°C				mW/°C
MD1123, MD1130		10.3	14.3	
MD1130F		5.71	11.4	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

MD1123
MD1130,F

MD1123
MD1130
CASE 654-07, STYLE 1

MD1130F
CASE 610-A04, STYLE 1



DUAL
AMPLIFIER TRANSISTOR

PNP SILICON

5

THERMAL CHARACTERISTICS

Characteristic		Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case		$R_{\theta JC}$			°C/W
	MD1123, MD1130		97	70	
	MD1130F		175	87.5	
Thermal Resistance, Junction to Ambient		$R_{\theta JA}$(1)			°C/W
	MD1123, MD1130		304	280	
	MD1130F		500	438	
			Junction to Ambient	Junction to Case	
Coupling Factors					%
	MD1123, MD1130		84	44	
	MD1130F		75	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)		$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current		I_{CBO}				
($V_{CB} = 50$ Vdc, $I_E = 0$)			—	—	10	nAdc
($V_{CB} = 50$ Vdc, $I_E = 0$, $T_A = 150°C$)			—	—	10	μAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	—	10	nAdc
ON CHARACTERISTICS						
DC Current Gain(2)		h_{FE}				—
($I_C = 10$ μAdc, $V_{CE} = 10$ Vdc)	MD1130,F		60	100	—	
($I_C = 100$ μAdc, $V_{CE} = 10$ Vdc)	MD1123		30	80	120	
	MD1130F		100	170	300	
($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc)	MD1130,F		100	180	—	
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	MD1123		50	75	200	
	MD1130,F		100	150	—	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

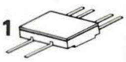
Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 Adc)		$V_{CE(sat)}$	—	0.18	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	—	0.8	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MD1123 MD1130,F	f_T	250 200	600 550	— —	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	3.5	4.0	pF
MATCHING CHARACTERISTICS						
DC Current Gain Ratio(3) (I_C = 100 μAdc, V_{CE} = 10 Vdc)	MD1123 MD1130,F	h_{FE1}/h_{FE2}	0.8 0.9	— —	1.0 1.0	—
Base-Emitter Voltage Differential (I_C = 100 μAdc, V_{CE} = 10 Vdc) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	MD1123 MD1130,F	$\lvert V_{BE1}-V_{BE2}\rvert$	— —	— —	10 5.0	mVdc
Base-Emitter Voltage Differential Change Due to Temperature — MD1121, MD1122 (I_C = 100 μAdc, V_{CE} = 10 Vdc, T_A = +25 to +125°C)	MD1130,F	$\Delta\lvert V_{BE1}/V_{BE2}\rvert$	—	—	10	mVdc

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(3) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

MD1129,F
MQ1129

MD1129
CASE 654-07, STYLE 1

MD1129F
CASE 610A-04, STYLE 1



MQ1129
CASE 607-04, STYLE 1

DUAL
AMPLIFIER TRANSISTOR

NPN SILICON

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		One Die	All Die Equal Power	
Total Power Dissipation @ $T_A = 25°C$	P_D			mW
MD1129		575	625	
MD129F		350	400	
MQ1129		400	600	
Derate above 25°C				mW/°C
MD1129		3.29	3.57	
MD1129F		2.9	2.28	
MQ1129		2.28	3.42	
Total Device Dissipation @ $T_C = 25°C$	P_D			Watts
MD1129		1.8	2.5	
MD1129F		1.0	2.0	
MQ1129		0.9	3.6	
Derate above 25°C				mW/°C
MD1129		10.3	14.3	
MD1129F		5.71	11.4	
MQ1129		5.13	20.5	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic		Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case		$R_{\theta JC}$			°C/W
	MD1129		97	70	
	MD1129F		175	87.5	
	MQ1129		195	48.8	
Thermal Resistance, Junction to Ambient		$R_{\theta JA}$(1)	304	280	°C/W
			500	438	
			438	292	

		Junction to Ambient	Junction to Case	Unit
Coupling Factors				%
	MD1129	84	44	
	MD1129F	75	0	
	MQ1129 (Q1-Q2)	57	0	
	(Q1-Q3 or Q1-Q4)	55	0	

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current	I_{CBO}				
($V_{CB} = 50$ Vdc, $I_E = 0$)		—	—	10	nAdc
($V_{CB} = 50$ Vdc, $I_E = 0$, $T_A = 150°C$)		—	—	10	μAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	10	nAdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

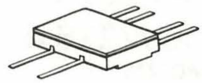
Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain(2)		h_{FE}				—
(I_C = 10 μAdc, V_{CE} = 10 Vdc)			60	—	—	
(I_C = 100 μAdc, V_{CE} = 10 Vdc)			100	—	300	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)			100	120	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)			100	140	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	MD1129, MQ1129		—	0.09	0.1	
	MD1129F		—	—	0.15	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	—	0.7	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(2) (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	200	250	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	3.5	8.0	pF
MATCHING CHARACTERISTICS (MD1129, MD1129F)						
DC Current Gain Ratio(3)		h_{FE1}/h_{FE2}				—
(I_C = 100 μAdc, V_{CE} = 10 Vdc)			0.9	—	1.0	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)			0.9	—	1.0	
Base-Emitter Voltage Differential		$\lvert V_{BE1}-V_{BE2}\rvert$				mVdc
(I_C = 100 μAdc, V_{CE} = 10 Vdc)			—	—	5.0	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)			—	—	5.0	
Base-Emitter Voltage Differential Change Due to Temperature		$\Delta(V_{BE1}-V_{BE2})$				mVdc
(I_C = 100 μAdc, V_{CE} = 10 Vdc, T_A = −55 to +25°C)			—	—	0.8	
(I_C = 100 μAdc, V_{CE} = 10 Vdc, T_A = +25 to +125°C)			—	—	1.0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(3) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

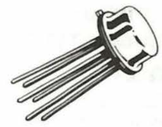
5

MD1132,F

MD1132F
CASE 610A-04, STYLE 1



MD1132
CASE 654-07, STYLE 1



DUAL
RF AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MD918 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CBO}	30		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		One Die	**Both Die**	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	550 3.14	600 3.42	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.4 8.0	2.0 11.4	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	Both Die Equal Power	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	87.5	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	319	292	°C/W
		Junction to Ambient	**Junction to Case**	**Unit**
Coupling Factors		83	40	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

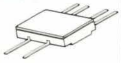
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 3.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 1.0$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$) ($V_{CB} = 15$ Vdc, $I_E = 0$, $T_A = 150°C$)	I_{CBO}	— —	— —	10 1.0	nAdc μAdc
ON CHARACTERISTICS					
DC Current Gain(2) ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	50	—	—	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	0.2	0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	—	0.7	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	600	800	—	—
Output Capacitance ($V_{CB} = 0$, $I_E = 0$, f = 140 kHz) ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 140 kHz)	C_{obo}	— —	1.5 1.3	3.0 1.7	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 140 kHz)	C_{ibo}	—	1.8	2.0	pF
MATCHING CHARACTERISTICS					
DC Current Gain Ratio(3) ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE1}/h_{FE2}	0.9	—	1.0	—
Base-Emitter Voltage Differential ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)	$\|V_{BE1}-V_{BE2}\|$	—	—	5.0	mVdc
Base-Emitter Voltage Differential Change Due to Temperature ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, $T_A = -55$ to $+25°C$) ($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc, $T_A = +25$ to $+125°C$)	$\Delta(V_{BE1}-V_{BE2})$	 — —	 — —	 0.8 1.0	mVdc

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(3) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

MD2218,A,F,AF
MD2219,A,F,AF
MQ2218,A
MQ2219,A

MD2218,A
MD2219,A
CASE 654-07, STYLE 1

MD2218F,AF
MD2219F,AF
CASE 610A-04, STYLE 1



MQ2218,A
MQ2219,A
CASE 607-04, STYLE 1

DUAL
AMPLIFIER TRANSISTOR
NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MD2218,A,F MD2219,A,F MQ2218,A MQ2219,A	MD2218AF MD2219AF	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	Vdc
Collector-Base Voltage	V_{CBO}	60	75	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	6.0	Vdc
Collector Current — Continuous	I_C	500		mAdc
		One Die	All Die Equal Power	
Total Device Dissipation	P_D			mW
@ T_A = 25°C				
MD2218,A, MD2219,A		575	625	
MD2218F,AF, MD2219F,AF		350	400	
MQ2218,A, MQ2219,A		400	600	mW/°C
Derate above 25°C				
MD2218,A, MD2219,A		3.29	3.57	
MD2218F,AF, MD2219F,AF		2.0	2.28	
MQ2218,A, MQ2219,A		2.28	3.42	
Total Device Dissipation	P_D			Watts
@ T_C = 25°C				
MD2218,A, MD2219,A		1.8	2.5	
MD2218F,AF, MD2219F,AF		1.0	2.0	
MQ2218,A, MQ2219,A		0.9	3.6	mW/°C
Derate above 25°C				
MD2218,A, MD2219,A		10.3	14.3	
MD2218F,AF, MD2219F,AF		5.71	11.4	
MQ2218,A, MQ2219,A		5.13	20.5	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic		Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case		$R_{\theta JC}$			°C/W
	MD2218,A, MD2219,A		97	70	
	MD2218F,AF, MD2219F,AF		175	87.5	
	MQ2218,A, MQ2219,A		195	48.8	
Thermal Resistance, Junction to Ambient		$R_{\theta JA}$(1)			°C/W
	MD2218,A, MD2219,A		304	280	
	MD2218,F,AF, MD2219,F,AF		500	438	
	MQ2218,A, MQ2219,A		438	292	
			Junction to Ambient	Junction to Case	
Coupling Factors					%
	MD2218,A, MD2219,A		84	44	
	MD2218F,AF, MD2219F,AF		75	0	
	MQ2218,A, MQ2219,A (Q1-Q2)		57	0	
	(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$				Vdc
	MD2218,A,F, MD2219,A,F, MQ2218,A, MQ2219,A		30	—	—	
	MD2218AF, MD2219AF		40	—	—	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$				Vdc
	MD2218,A,F, MD2219,A,F, MQ2218,A, MD2219,A		60	—	—	
	MD2218AF, MD2219AF		75	—	—	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$				Vdc
	MD2218,A,F, MD2219,A,F, MQ2218,A, MQ2219,A		5.0	—	—	
	MD2218AF, MD2219AF		6.0	—	—	
Collector Cutoff Current (V_{CE} = 50 Vdc, $V_{EB(off)}$ = 3.0 Vdc)		I_{CEV}				nAdc
	MD2218,F, MD2219,F, MQ2218,A		20	—	—	
	MD2218A,AF, MD2219A,AF, MQ2219,A		15	—	—	
Base Cutoff Current (V_{CE} = 50 Vdc, $V_{EB(off)}$ = 3.0 Vdc)		I_{BL}	30	—	—	nAdc
ON CHARACTERISTICS(2)						
DC Current Gain		h_{FE}				—
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	MD2218,A,F,AF, MQ2218,A		20	50	—	
	MD2219,A,F,AF, MQ2219,A		35	45	—	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	MD2218,A,F,AF, MQ2218,A		25	55	—	
	MD2219,A,F,AF, MQ2219,A		50	55	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MD2218,A,F,AF, MQ2218,A		35	65	—	
	MD2219,A,F,AF, MQ2219,A		75	85	—	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)	MD2218,A,F,AF, MQ2218,A		20	65	—	
	MD2219,A,F,AF, MQ2219,A		50	65	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MD2218,AF,AF, MQ2218,A		40	30	120	
	MD2219,A,F,AF, MQ2219,A		100	120	300	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)	MD2218,A, MQ2218,A		25	75	—	
	MD2219,A, MQ2219,A		30	75	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	MD2218,A,F, MD2219,A,F, MQ2218,A, MQ2219,A		—	0.2	0.4	
	MD2218AF, MD2219AF		—	—	0.3	
(I_C = 300 mAdc, I_B = 30 mAdc)	MD2218,A,F, MD2219,A,F, MQ2218,A, MQ2219,A		—	0.35	1.2	
	MD2218AF, MD2219AF		—	—	0.9	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	MD2218,A,F, MD2219,A,F, MQ2218,A, MQ2219,A		0.6	0.95	1.3	
	MD2218AF, MD2219AF		0.6	1.0	1.2	
(I_C = 300 mAdc, I_B = 30 mAdc)	MD2218,A,F, MD2219,A,F, MQ2218,A, MQ2219,A		—	—	2.0	
	MD2218AF, MD2219AF		—	—	1.8	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	250	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	3.5	8.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}				pF
	MD2218,A,F, MD2219,A,F, MQ2218,A, MQ2219,A		—	15	20	
	MD2218AF, MD2219AF		—	18	25	

5

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
SWITCHING CHARACTERISTICS						
Delay Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, $V_{BE(off)}$ = 0.5 Vdc, I_{B1} = 15 mAdc) MD2218,F, MD2219,F MD2218A,AF, MD2219A,AF	t_d	— —	— —	20 15	µs
Rise Time	MD2218,F, MD2219,F MD2218A,AF, MD2219A,AF	t_r	— —	— —	40 30	µs
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) MD2218,F, MD2219,F MD2218A,AF, MD2219A,AF	t_s	— —	— —	280 250	µs
Fall Time	MD2218,F, MD2219,F MD2218A,AF, MD2219A,AF	t_f	— —	— —	70 60	µs

(2) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

5

FIGURE 1 — NORMALIZED DC CURRENT GAIN

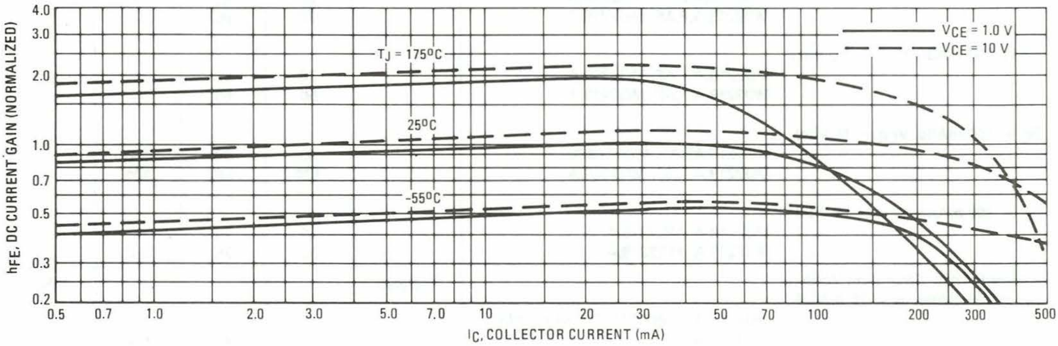


FIGURE 2 — "ON" VOLTAGES

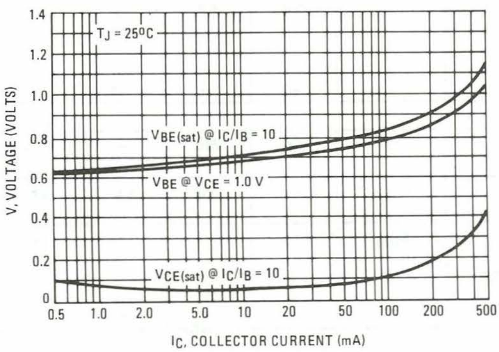
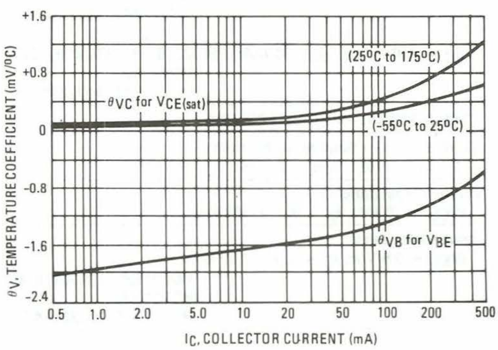


FIGURE 3 — TEMPERATURE COEFFICIENTS



NOISE FIGURE

(V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 4 — FREQUENCY EFFECTS

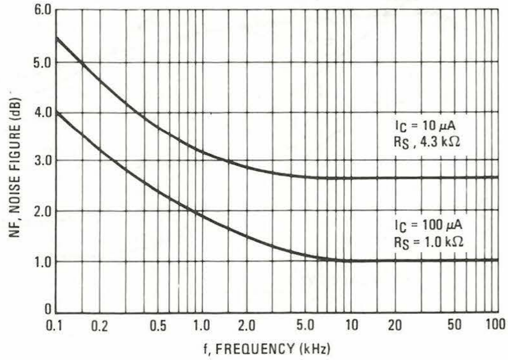


FIGURE 5 — SOURCE RESISTANCE EFFECTS

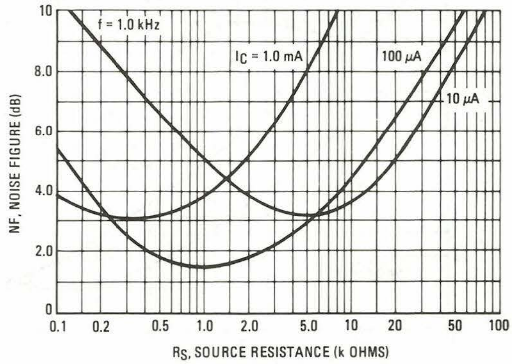


FIGURE 6 — CURRENT-GAIN-BANDWIDTH PRODUCT

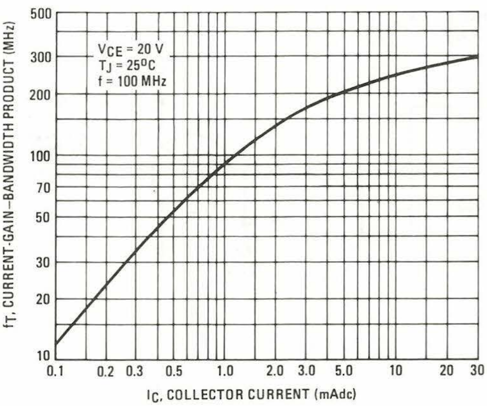
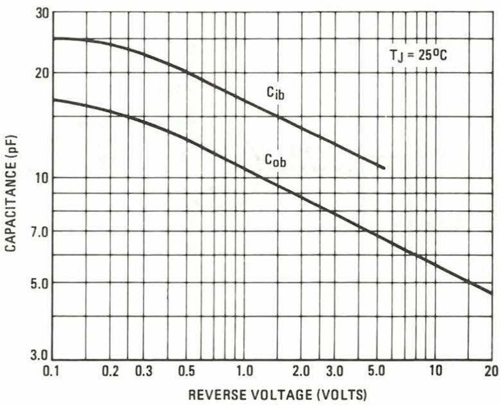


FIGURE 7 — CAPACITANCES



SWITCHING TIME CHARACTERISTICS

FIGURE 8 — TURN-ON TIME

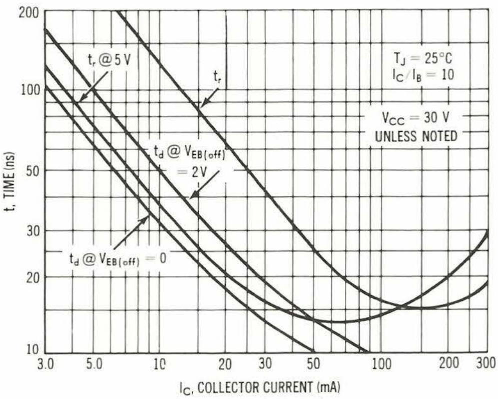


FIGURE 9 — CHARGE DATA

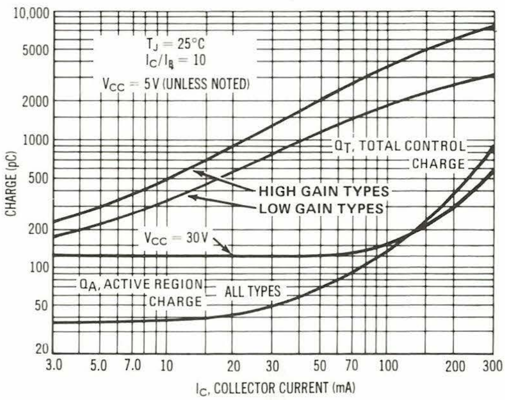


FIGURE 10 – TURN-OFF BEHAVIOR

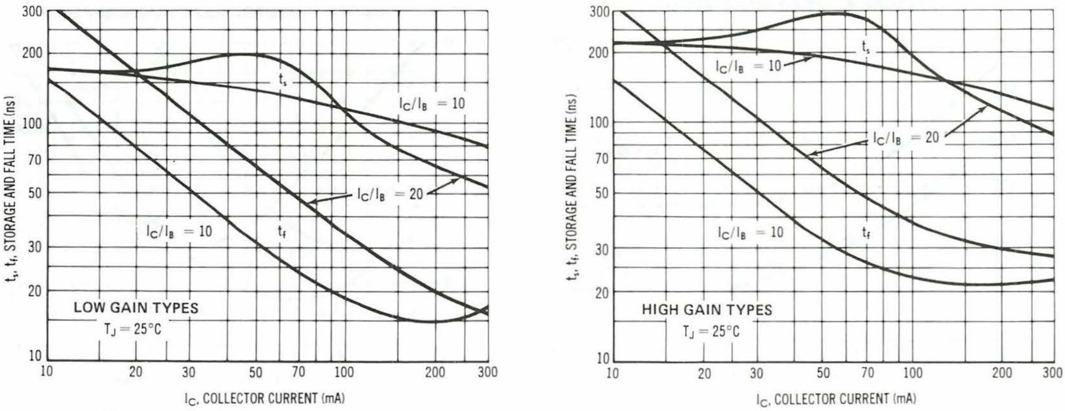


FIGURE 11 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

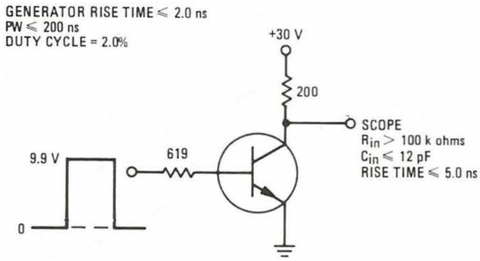
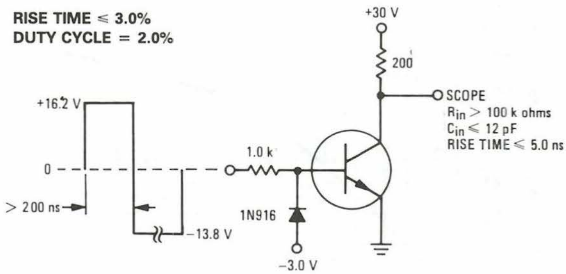


FIGURE 12 – STORAGE TIME AND FALL TIME EQUIVALENT TEST CIRCUIT



MD2369,A,B
MD2369F,AF,BF
MQ2369

MD2369,A,B
CASE 654-07, STYLE 1

MD2369F,AF,BF
CASE 610A-04, STYLE 1

MQ2369
CASE 607-04, STYLE 1

DUAL
GENERAL PURPOSE TRANSISTOR

NPN SILICON

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		One Die	**All Die Equal Power**	
Total Device Dissipation @ $T_A = 25°C$	P_D			mW
MD2369,A,B		550	600	
MD2369F,AF,BF		350	400	
MQ2369		400	600	
Derate above 25°C				mW/°C
MD2369,A,B		3.14	3.42	
MD2369F,AF,BF		2.0	2.28	
MQ2369		2.28	3.42	
Total Device Dissipation @ $T_C = 25°C$	P_D			Watts
MD2369,A,B		1.4	2.0	
MD2369F,AF,BF		0.7	1.4	
MQ2369		0.7	2.8	
Derate above 25°C				mW/°C
MD2369,A,B		8.0	11.4	
MD2369F,AF,BF		4.0	80	
MQ2369		4.0	16	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic		Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case		$R_{\theta JC}$			°C/W
	MD2369,A,B		125	87.5	
	MD2369F,AF,BF		250	125	
	MQ2369		250	62.6	
Thermal Resistance, Junction to Ambient		$R_{\theta JA}$(1)			°C/W
	MD2369,A,B		319	292	
	MD2369F,AF,BF		500	438	
	MQ2369		438	292	
			Junction to Ambient	**Junction to Case**	
Coupling Factor	MD2369,A,B		83	40	%
	MD2369F,AF,BF		75	0	
	MQ2369 (Q1-Q2)		57	0	
	(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current	I_{CBO}				μAdc
($V_{CB} = 20$ Vdc, $I_E = 0$)		—	—	0.03	
($V_{CB} = 20$ Vdc, $I_E = 0$, $T_A = +150°C$)		—	—	30	
ON CHARACTERISTICS(2)					
DC Current Gain	h_{FE}				—
($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)		40	95	140	
($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc, $T_A = -55°C$)		20	—	—	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	—	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	0.7	—	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(2) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	500	800	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	—	4.0	pF
Input Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 100 MHz)		C_{ibo}	—	—	4.0	pF
SWITCHING CHARACTERISTICS						
Storage Time (V_{CC} = 10 Vdc, I_C = I_{B1} = I_{B2} = 10 mAdc)		t_s	—	—	13	ns
Turn-On Time (V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc)		t_{on}	—	—	15	ns
Turn-Off Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc)		t_{off}	—	—	20	ns
MATCHING CHARACTERISTICS						
DC Current Gain Ratio(3) (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	MD2369A, MD2369AF MD2369B, MD2369BF	h_{FE1}/h_{FE2}	0.9 0.8	— —	1.0 1.0	—
Base-Emitter Voltage Differential (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	MD2369A, MD2369AF MD2369B, MD2369BF	$\|V_{BE1}-V_{BE2}\|$	— —	— —	5.0 10	mVdc
Base-Emitter Voltage Differential Gradient (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc, T_A = −55 to +125°C)	MD2369A, MD2369AF MD2369B, MD2369BF	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	— —	— —	10 20	µV/°C

(2) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.
(3) The lowest h_{FE} reading is taken as h_{FE1} for this test.

5

FIGURE 1 – STORAGE TIME TEST CIRCUIT

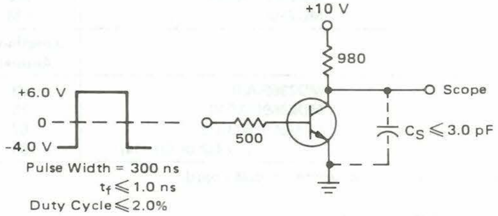


FIGURE 2 – TURN-ON TIME

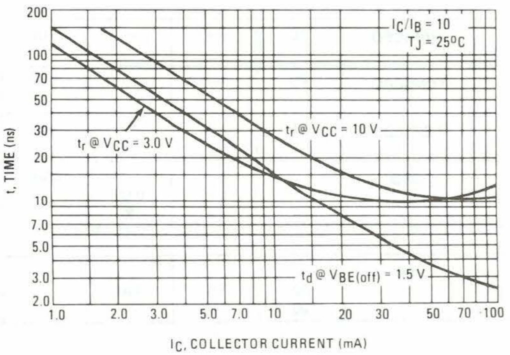


FIGURE 3 – TURN-OFF TIME

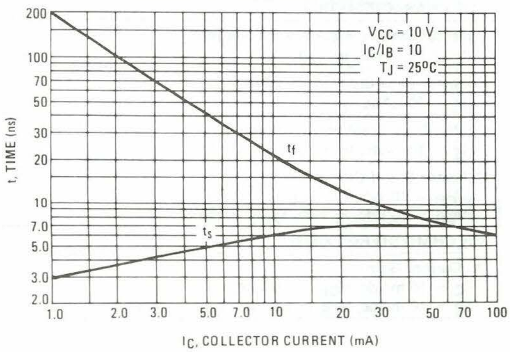


FIGURE 4 – TURN-ON TEST CIRCUIT

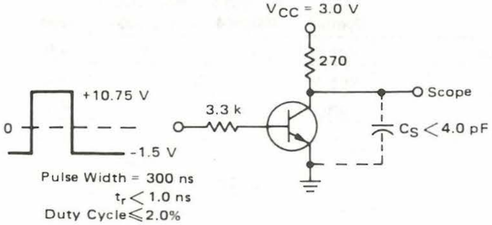


FIGURE 5 – TURN-OFF TEST CIRCUIT

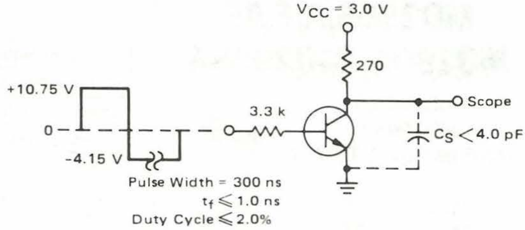


FIGURE 6 – CAPACITANCE

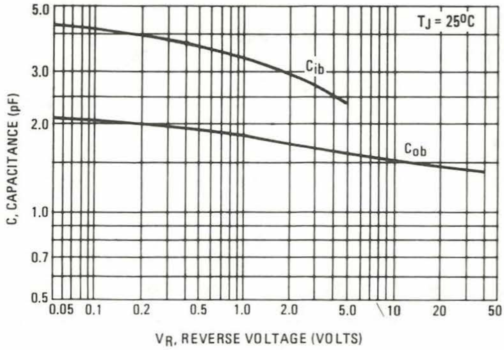


FIGURE 7 – CURRENT-GAIN–BANDWIDTH PRODUCT

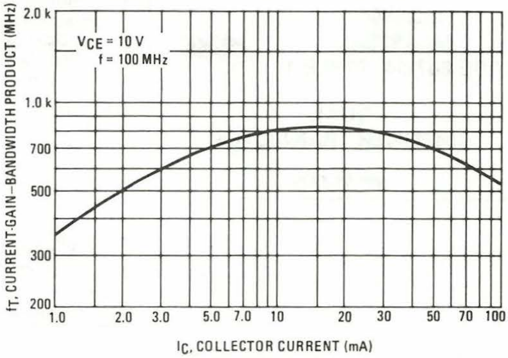


FIGURE 8 – DC CURRENT GAIN

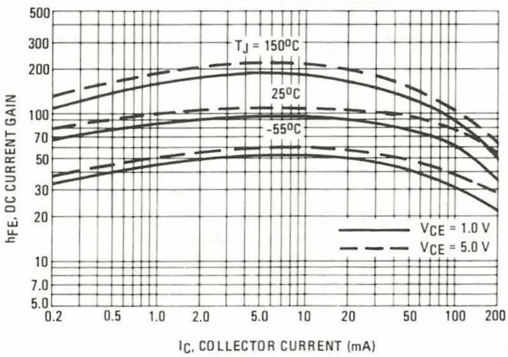


FIGURE 9 – "ON" VOLTAGES

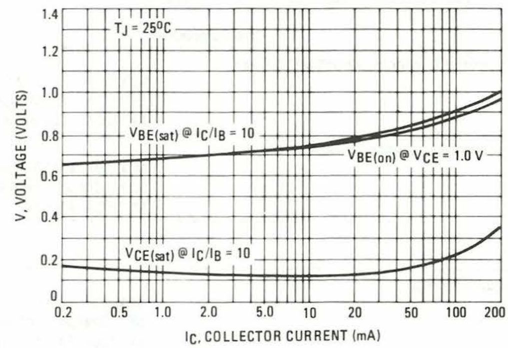


FIGURE 10 – COLLECTOR SATURATION REGION

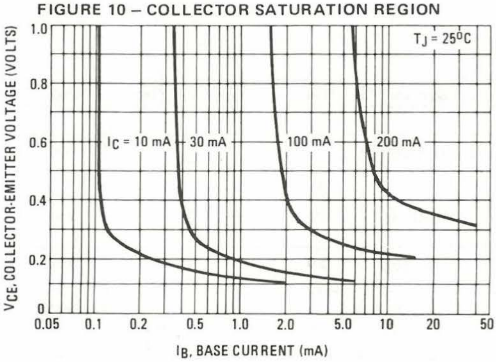
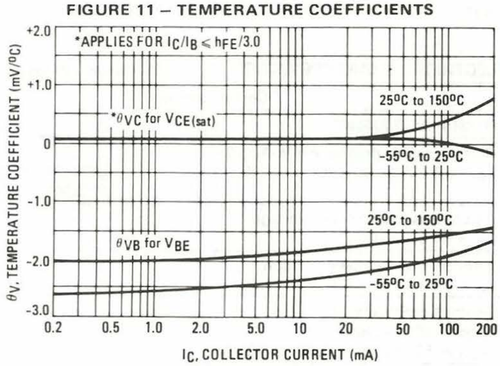


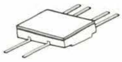
FIGURE 11 – TEMPERATURE COEFFICIENTS



MD2904,A,F,AF
MD2905,A,F,AF
MQ2904, MQ2905A

MD2904,A
MD2905,A
CASE 654-07, STYLE 1

MD2904F,AF
MD2905F,AF
CASE 610A-04, STYLE 1



MQ2904
MQ2905A
CASE 607-04, STYLE 1

DUAL
AMPLIFIER TRANSISTOR

PNP SILICON

5

MAXIMUM RATINGS

Rating	Symbol	MD2904,F MD2905,F MQ2904	MD2904A,AF MD2905A,AF MQ2905A	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
		One Die	All Die Equal Power	
Total Device Dissipation @ T_A = 25°C	P_D			mW
MD2904,A, MD2905,A		575	625	
MD2904F,AF, MD2905,AF		350	400	
MQ2904, MQ2905A		400	600	mW/°C
Derate above 25°C				
MD2904,A, MD2905,A		3.29	3.57	
MD2904,F,AF, MD2905F,AF		2.0	2.28	
MQ2904, MQ2905A		2.28	3.42	
Total Device Dissipation @ T_C = 25°C	P_D			Watts
MD2904,A, MD2905,A		1.8	2.5	
MD2904F,AF, MD2905F,AF		1.0	2.0	
MQ2904, MQ2905A		0.9	3.6	mW/°C
Derate above 25°C				
MD2904,A, MD2905,A		10.3	14.3	
MD2904F,AF, MD2905F,AF		5.71	11.4	
MQ2904, MQ2905A		5.13	20.5	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD2904,A, MD2905,A		97	70	
MD2904F,AF, MD2905F,AF		175	87.5	
MQ2904, MQ2905A		195	48.8	
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)			°C/W
MD2904,A, MD2905,A		304	280	
MD2904F,AF, MD2905F,AF		500	438	
MQ2904, MQ2905A		438	292	
		Junction to Ambient	Junction to Case	
Coupling Factor				%
MD2904,A, MD2905,A		84	44	
MD2904F,AF, MD2905F,AF		75	0	
MQ2904, MQ2905A (Q1-Q2)		57	0	
(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$				Vdc
MD2904, MD2905		40	—	—	
MD2904A, MD2905A		60	—	—	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current	I_{CBO}				μAdc
(V_{CB} = 50 Vdc, I_E = 0)		—	—	0.020	
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)		—	—	30	

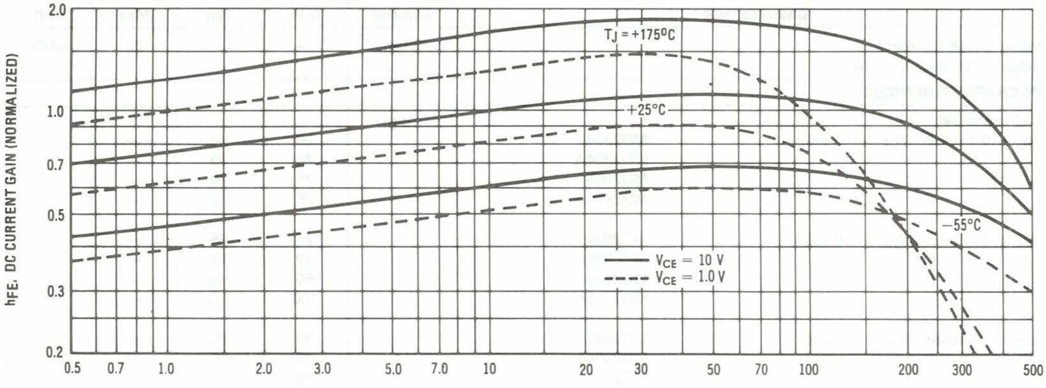
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	—	30	nAdc
ON CHARACTERISTICS(2)						
DC Current Gain		h_{FE}				—
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	MD2904		20	50	—	
	MD2904A		40	70	—	
	MD2905		35	70	—	
	MD2905A		75	150	—	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	MD2904		25	75	—	
	MD2904A		40	75	—	
	MD2905		50	100	—	
	MD2905A		100	175	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MD2904		35	90	—	
	MD2904A		40	90	—	
	MD2905		75	110	—	
	MD2905A		100	200	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MD2904,A,		40	90	120	
	MD2905,A		100	200	300	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	MD2904		20	60	—	
	MD2904A		40	80	—	
	MD2905		30	130	—	
	MD2905A		50	150	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	0.25	0.4	
(I_C = 500 mAdc, I_B = 50 mAdc)			—	0.5	1.6	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	0.88	1.3	
(I_C = 500 mAdc, I_B = 50 mAdc)			—	1.0	2.6	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(3) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	320	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	5.8	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	16	30	pF
SWITCHING CHARACTERISTICS						
Turn-On Time	(V_{CC} = 30 Vdc, V_{BE} = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_{on}	—	—	45	ns
Delay Time		t_d	—	—	12	ns
Rise Time		t_r	—	—	35	ns
Turn-Off Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_{off}	—	—	130	ns
Storage Time		t_s	—	—	100	ns
Fall Time		t_f	—	—	40	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(3) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

5

FIGURE 1 — DC CURRENT GAIN



5

FIGURE 2 — "ON" VOLTAGES

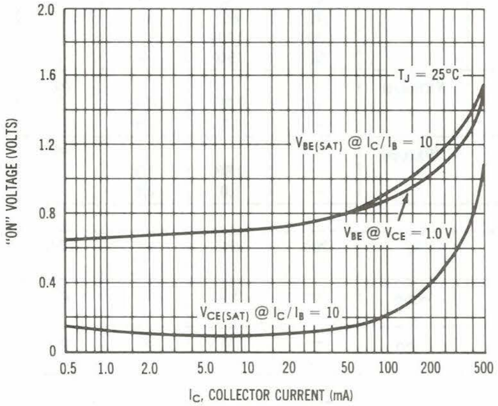
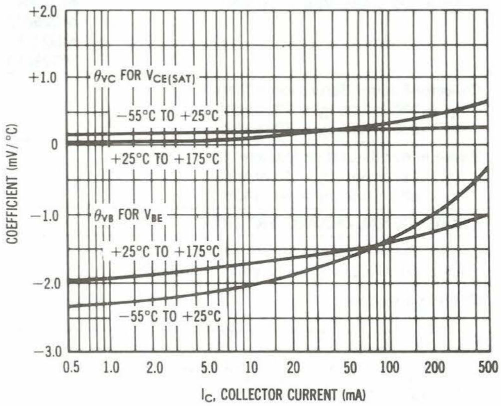


FIGURE 3 — TEMPERATURE COEFFICIENTS



NOISE FIGURE

$V_{CE} = 10\ V$, $T_A = 25°C$

FIGURE 4 — FREQUENCY EFFECTS

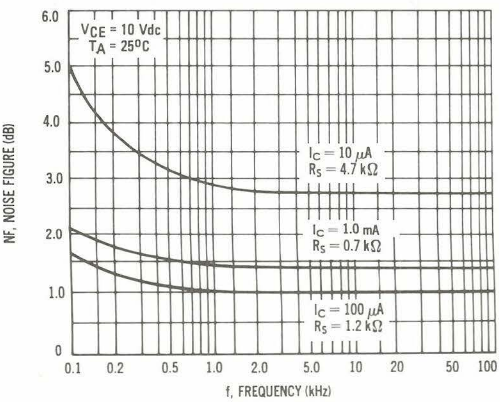


FIGURE 5 — SOURCE RESISTANCE EFFECTS

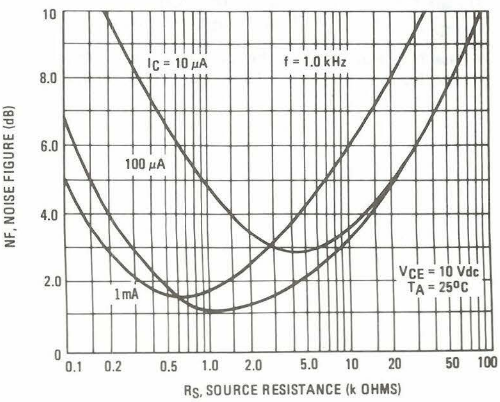


FIGURE 6 – CURRENT-GAIN BANDWIDTH PRODUCT

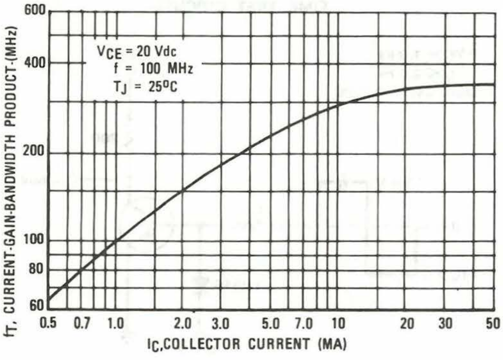


FIGURE 7 – CAPACITANCE

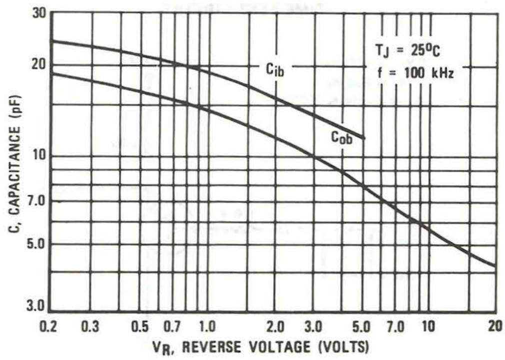


FIGURE 8 – TURN ON TIME

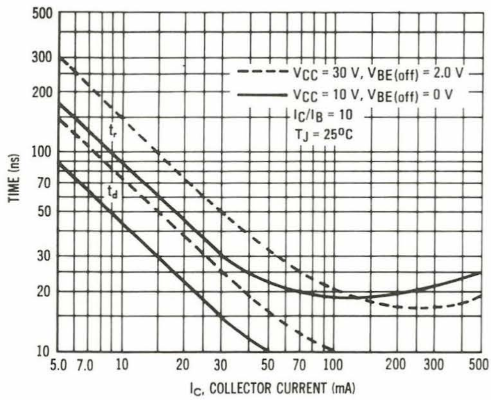


FIGURE 9 – CHARGE DATA

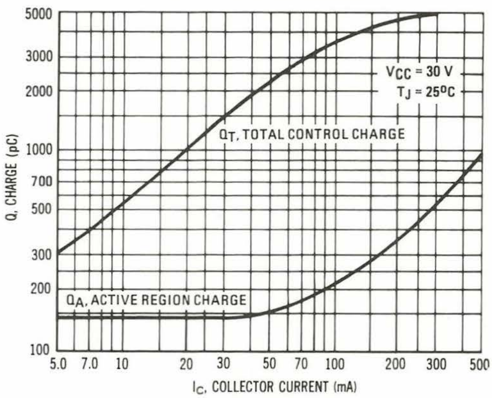


FIGURE 10 – STORAGE TIME

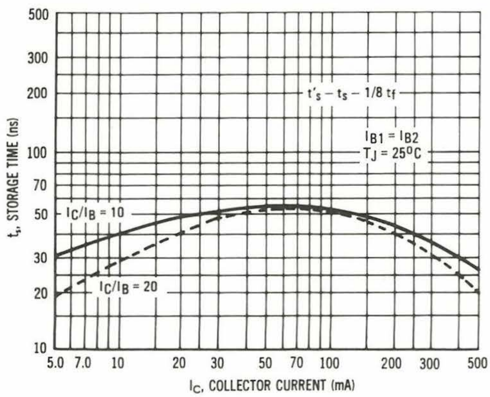


FIGURE 11 – FALL TIME

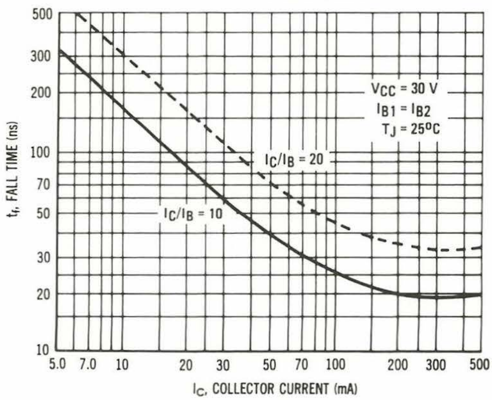


FIGURE 12 – DELAY AND RISE TIME TEST CIRCUIT

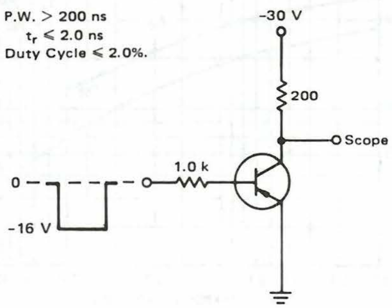
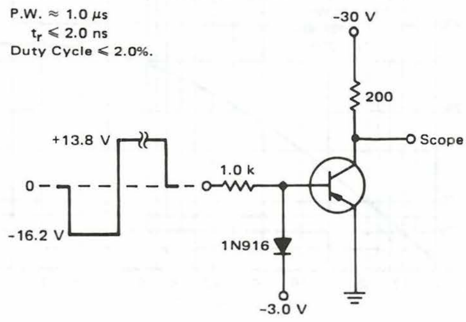


FIGURE 13 – STORAGE AND FALL TIME TEST CIRCUIT



5

MD3250,A,F,AF
MD3251,A,F,AF
MQ3251

MD3250,A
MD3251,A
CASE 654-07, STYLE 1

MD3250F,AF
MD3251F,AF
CASE 610A-04, STYLE 1

MQ3251
CASE 607-04, STYLE 1

DUAL
AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	50		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		One Die	All Die Equal Power	
Total Device Dissipation @ $T_A = 25°C$	P_D			mW
MD3250,A, MD3251,A		575	625	
MD3250F,AF, MD3251F,AF		350	400	
MQ3251		400	600	
Derate above 25°C				mW/°C
MD3250,A, MD3251,A		3.29	3.57	
MD3250F,AF, MD3251F,AF		2.0	2.28	
MQ3251		2.28	3.42	
Total Device Dissipation @ $T_C = 25°C$	P_D			Watts
MD3250,A, MD3251,A		1.8	2.5	
MD3250F,AF, MD3251F,AF		1.0	2.0	
MQ3251		0.9	3.6	
Derate above 25°C				mW/°C
MD3250,A, MD3251,A		10.3	14.3	
MD3250F,AF, MD3251F,AF		5.71	11.4	
MQ3251		5.13	20.5	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD3251,A, MD3251,A		97	70	
MD3250F,AF, MD3251F,AF		175	87.5	
MQ3251		195	48.8	
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)			°C/W
MD3250,A, MD3251,A		304	280	
MD3250F,AF, MD3251F,AF		500	438	
MQ3251		438	292	
		Junction to Ambient	Junction to Case	
Coupling Factors				%
MD3250,A, MD3251,A		84	44	
MD3250F,AF, MD3251F,AF		75	0	
MQ3251 (Q1-Q2)		57	0	
(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	50	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current	I_{CBO}				
($V_{CB} = 40$ Vdc, $I_E = 0$)		—	—	10	nAdc
($V_{CB} = 40$ Vdc, $I_E = 0$, $T_A = 150°C$)		—	—	10	μAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	10	nAdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS(2)						
DC Current Gain		h_{FE}				—
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	MD3250,A,F,AF		25	75	—	
	MD3251,A,F,AF		50	100	—	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	MD3250,A,F,AF		50	82	150	
	MD3251,A,F,AF		80	170	300	
	MQ3251		80	170	—	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = −55°C)	MD3250,A,F,AF		25	35	—	
	MD3251,A,F,AF		50	75	—	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MD3250,A,F,AF		50	87	150	
	MD3251,A,F,AF		100	180	300	
	MQ3251		100	180	—	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MD3250,A,F,AF		50	92	—	
	MD3251,A,F,AF		100	190	—	
	MQ3251		100	190	300	
(I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	MD3250,A,F,AF		15	50	—	
	MD3251,A,F,AF		30	90	—	
	MQ3251		30	90	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			—	0.11	0.25	
(I_C = 50 mAdc, I_B = 5.0 mAdc)			—	0.18	0.5	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			0.6	0.78	0.9	
(I_C = 50 mAdc, I_B = 5.0 mAdc)			—	0.88	1.2	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product		f_T				MHz
(I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MD3250,A,F,AF		200	600	—	
	MD3251,A,F,AF		250	600	—	
	MQ3251		300	600	—	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	2.5	6.0	pF
Input Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	6.0	8.0	pF
MATCHING CHARACTERISTICS (MD3250,A,F,AF & MD3251,A,F,AF ONLY)						
DC Current Gain Ratio(3)		h_{FE1}/h_{FE2}				—
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)			0.9	—	1.0	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)			0.9	—	1.0	
Base-Emitter Voltage Differential		$\|V_{BE1}-V_{BE2}\|$				mVdc
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)			—	—	3.0	
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)			—	—	5.0	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)			—	—	5.0	
Base-Emitter Voltage Differential Change Due to Temperature		$\Delta\|V_{BE1}-V_{BE2}\|$				mVdc
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = −55 to +25°C)			—	—	0.8	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = +25 to +125°C)			—	—	1.0	

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(3) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

5

FIGURE 1 – CAPACITANCE

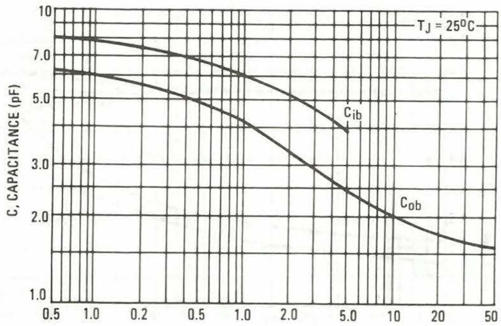
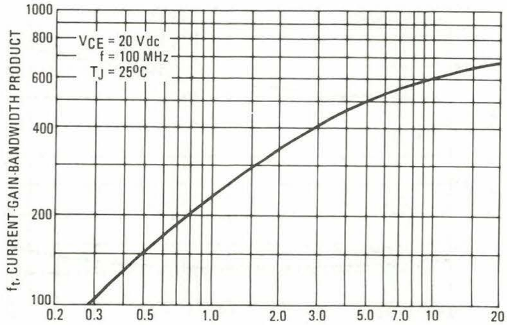


FIGURE 2 – CURRENT-GAIN BANDWIDTH PRODUCT



NOISE FIGURE VARIATIONS

(V_{CE} = 6.0 V, $T_A = 25^oC$)

FIGURE 3 – EFFECTS OF FREQUENCY

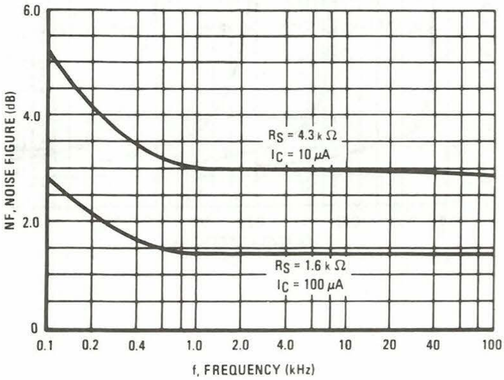


FIGURE 4 – EFFECTS OF SOURCE RESISTANCE

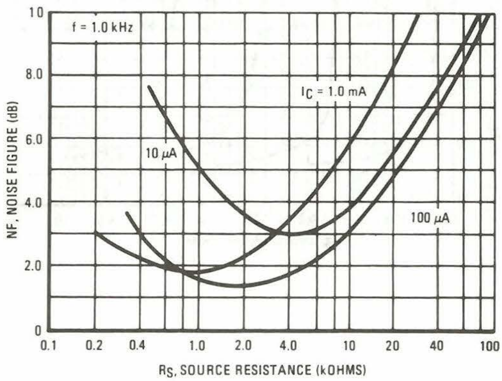


FIGURE 5 – DC CURRENT GAIN

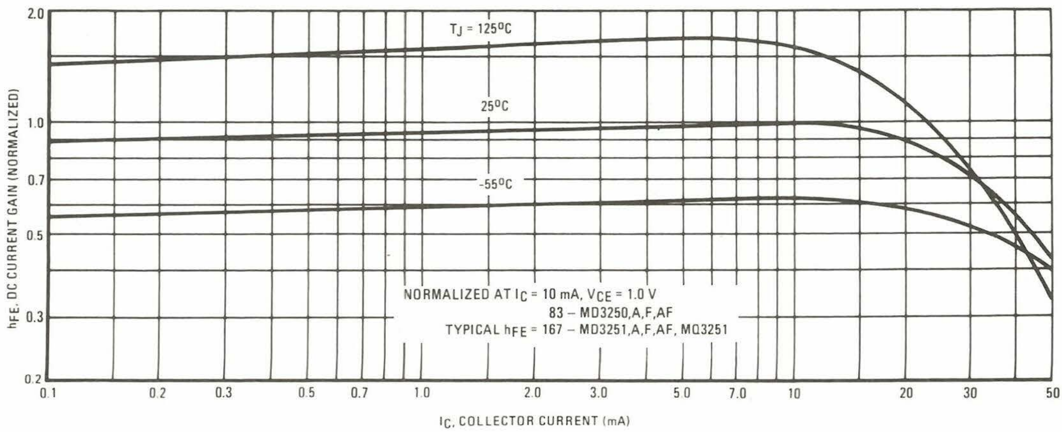


FIGURE 6 – "ON" VOLTAGE

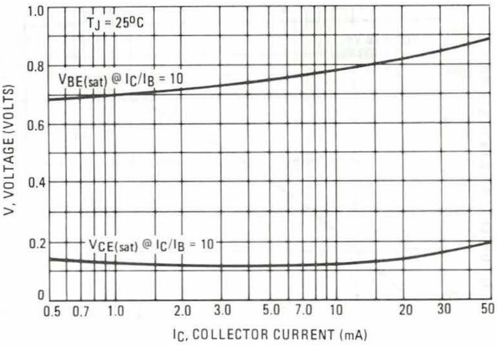


FIGURE 7 – TEMPERATURE COEFFICIENTS

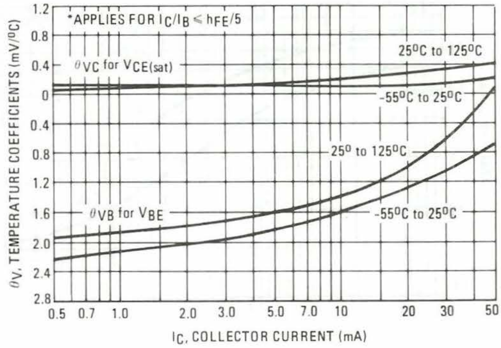
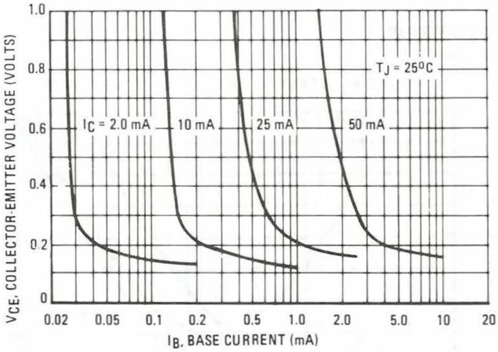
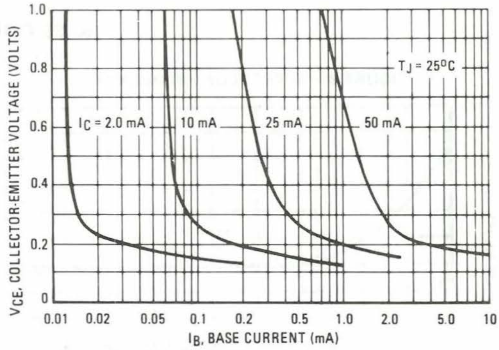


FIGURE 8 – COLLECTOR SATURATION REGION

MD3250



MD3251, MQ3251



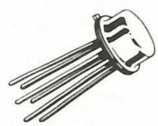
5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		One Die	Both Die Equal Power	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	575 3.29	625 3.57	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.8 10.3	2.5 14.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

MD3409
MD3410

CASE 654-07, STYLE 1



DUAL AMPLIFIER TRANSISTOR

NPN SILICON

5

Refer to MD2218 for graphs.

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	Both Die Equal Power	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	70	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	304	280	°C/W
		Junction to Ambient	Junction to Case	
Coupling Factors		84	44	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, I_B = 0)		$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)		I_{CBO}	— —	— —	10 10	nAdc μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	—	10	nAdc
ON CHARACTERISTICS						
DC Current Gain(2) (I_C = 10 μAdc, V_{CE} = 10 Vdc) (I_C = 100 μAdc, V_{CE} = 10 Vdc) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc)	 MD3410 Both Devices Both Devices Both Devices	h_{FE}	 20 30 40 50	 40 50 60 65	 100 120 160 200	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	—	0.09	0.15	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	—	0.7	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	250	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	3.5	8.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ibo}	—	15	25	pF
MATCHING CHARACTERISTICS						
Base-Emitter Voltage Differential Change Due to Temperature (I_C = 100 μAdc, V_{CE} = 10 Vdc, T_A = −55°C to +25°C) (I_C = 100 μAdc, V_{CE} = 10 Vdc, T_A = +25°C to +125°C)	 MD3409 MD3410 MD3409 MD3410	$\|V_{BE1}-V_{BE2}\|$	 — — — —	 — — — —	 1.6 0.8 2.0 1.0	mVdc

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MD3467,F
MQ3467

MD3467
CASE 654-07, STYLE 1

MD3467F
CASE 610A-04, STYLE 1

MQ3467
CASE 607-04, STYLE 1

DUAL AMPLIFIER TRANSISTOR

PNP SILICON

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	1.5		Adc
		One Die	**All Die Equal Power**	
Total Device Dissipation @ T_A = 25°C	P_D			mW
MD3467		600	650	
MD3467F		350	400	
MQ3467		400	600	
Derate above 25°C				mW/°C
MD3467		3.42	3.7	
MD3467F		2.0	2.28	
MQ3467		2.28	3.42	
Total Device Dissipation @ T_C = 25°C	P_D			Watts
MD3467		2.1	3.0	
MD3467F		1.25	2.5	
MQ3467		1.0	4.0	
Derate above 25°C				mW/°C
MD3467		12	17.2	
MD3467F		7.15	14.3	
MQ3467		5.71	22.8	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD3467		83.3	58.3	
MD3467F		140	70	
MQ3467		175	43.8	
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)			°C/W
MD3467		292	270	
MD3467F		500	438	
MQ3467		438	292	
		Junction to Ambient	**Junction to Case**	
Coupling Factors				%
MD3467		85	40	
MD3467F		75	0	
MQ3467 (Q1-Q2)		57	0	
(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0, T_A = 100°C)	I_{CBO}	—	—	10	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	—	100	nAdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	20	—	—	—
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{CE(sat)}$	—	0.32	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{BE(sat)}$	—	0.95	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	150	220	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)		C_{obo}	—	8.5	20	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)		C_{ibo}	—	22	80	pF
SWITCHING CHARACTERISTICS						
Delay Time	(V_{CC} = 30 Vdc, V_{BE} = 2.0 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc)	t_d	—	7.0	10	ns
Rise Time		t_r	—	17	30	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_s	—	58	80	ns
Fall Time		t_f	—	14	30	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

5

FIGURE 1 — DC CURRENT GAIN

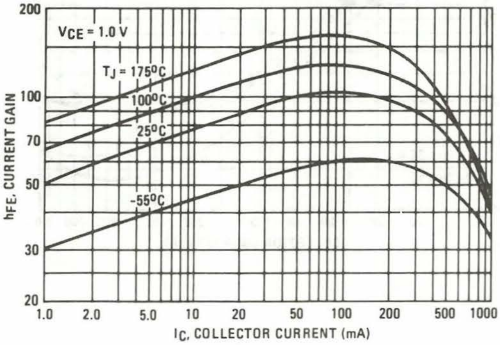


FIGURE 2 — COLLECTOR SATURATION REGION

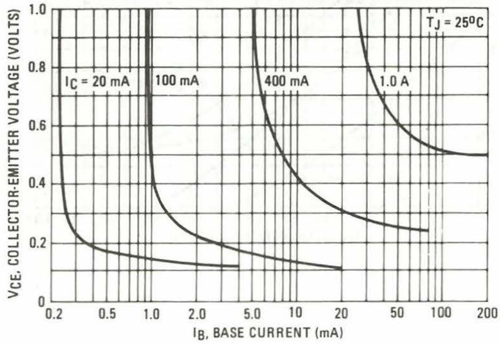


FIGURE 3 — "ON" VOLTAGE

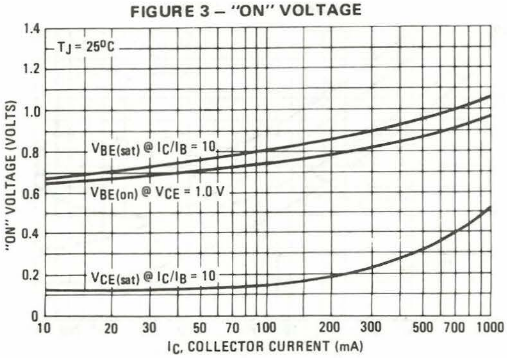


FIGURE 4 — TEMPERATURE COEFFICIENTS

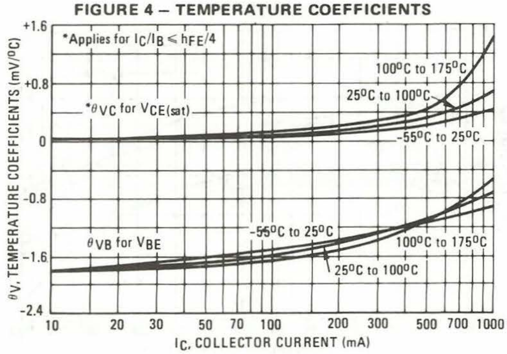


FIGURE 5 — ACTIVE REGION SAFE OPERATING AREA

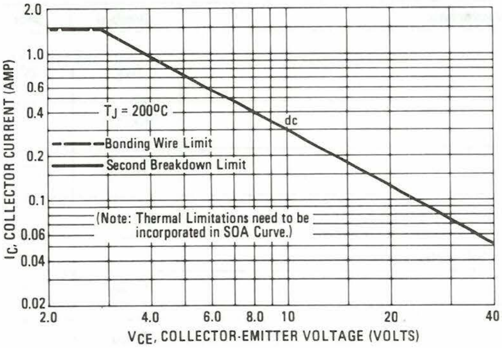


FIGURE 6 — TURN-ON TIME

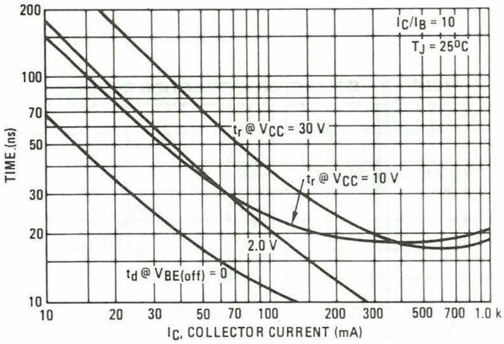


FIGURE 7 — RISE AND FALL TIME

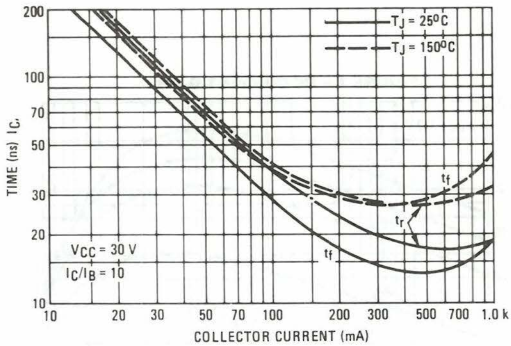


FIGURE 8 — STORAGE TIME

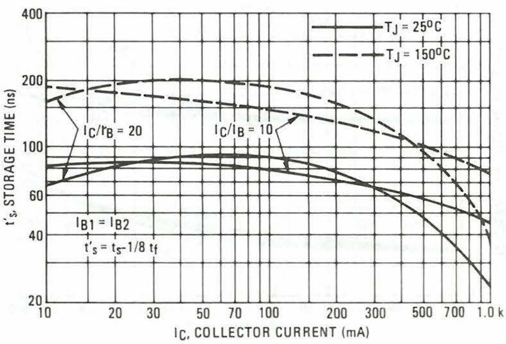


FIGURE 9 — FALL TIME

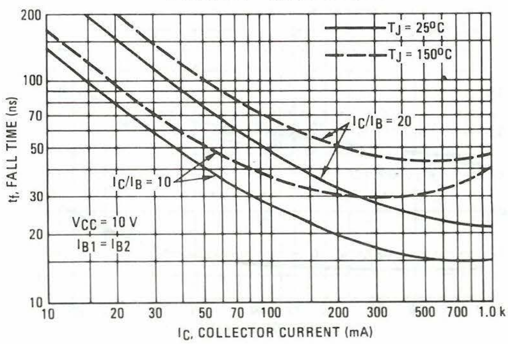


FIGURE 10 – SWITCHING TIME TEST CIRCUIT

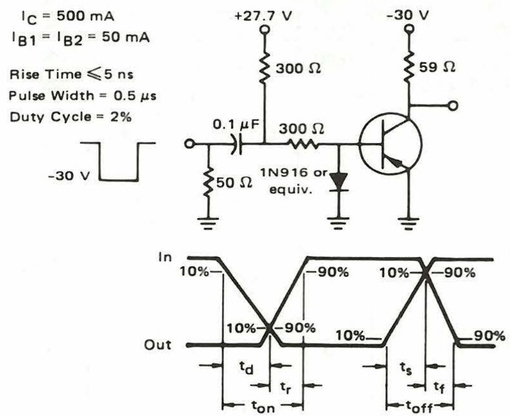
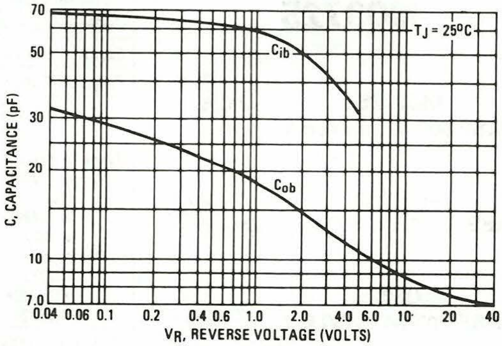


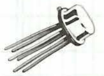
FIGURE 11 – CAPACITANCE



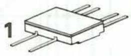
5

MD3725,F
MQ3725

MD3725
CASE 654-07, STYLE 1



MD3725F
CASE 610A-04, STYLE 1



MQ3725
CASE 607-04, STYLE 1

DUAL
AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	65		Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
		One Die	**All Die Equal Power**	
Total Device Dissipation @ $T_A = 25°C$	P_D			mW
MD3725		600	650	
MD3725F		350	400	
MQ3725		400	600	
Derate above 25°C				mW/°C
MD3725		3.42	3.7	
MD3725F		2.0	2.28	
MQ3725		2.28	3.42	
Total Device Dissipation @ $T_C = 25°C$	P_D			Watts
MD3725		2.1	3.0	
MD3725F		1.25	2.5	
MQ3725		1.0	4.0	
Derate above 25°C				mW/°C
MD3725		12	17.2	
MD3725F		7.15	14.3	
MQ3725		5.71	22.8	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic		Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case		$R_{\theta JC}$			°C/W
	MD3725		83.3	58.3	
	MD3725F		140	70	
	MQ3725		175	43.8	
Thermal Resistance, Junction to Ambient		$R_{\theta JA}$(1)			°C/W
	MD3725		292	270	
	MD3725F		500	438	
	MQ3725		433	292	
			Junction to Ambient	**Junction to Case**	
Coupling Factor					%
	MD3725		85	40	
	MD3725F		75	0	
	MQ3725 (Q1-Q2)		57	0	
	(Q1-Q3, Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0) MD3725F	$V_{(BR)CES}$	65	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	65	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current	I_{CBO}				
(V_{CB} = 40 Vdc, I_E = 0)		—	0.12	1.7	μAdc
(V_{CB} = 40 Vdc, I_E = 0, T_A = 100°C)		—	—	120	μAdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS(2)					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	50 30	— —	150 —	—
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	— —	0.19 0.30	0.26 0.45	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	— 0.80	— —	0.86 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	200	—	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	—	10	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	—	65	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc, $V_{BE(off)}$ = 3.8 Vdc)	t_{on}	—	20	45	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_{off}	—	50	75	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

5

TYPICAL DC CHARACTERISTICS

FIGURE 1 – DC CURRENT GAIN

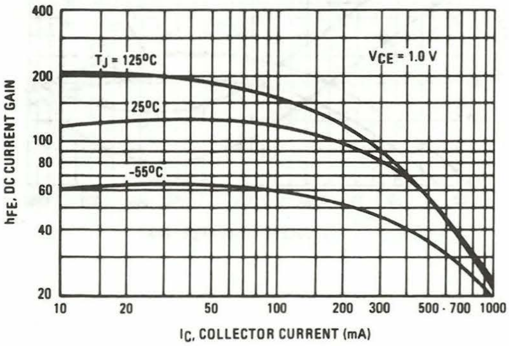


FIGURE 2 – "ON" VOLTAGES

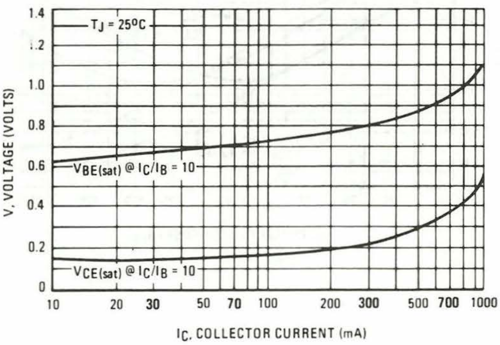


FIGURE 3 – COLLECTOR SATURATION REGION

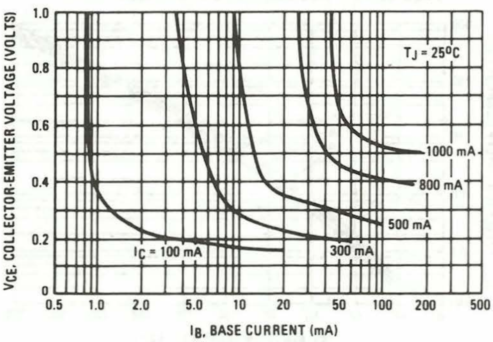
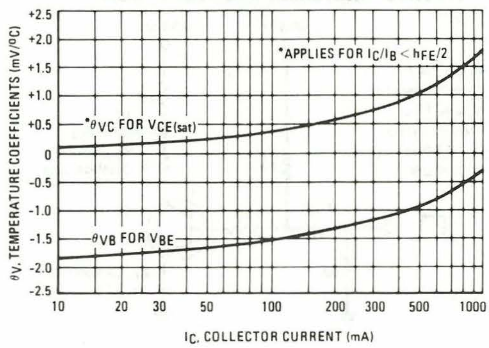


FIGURE 4 – TEMPERATURE COEFFICIENTS



5

TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 5 – CURRENT-GAIN – BANDWIDTH PRODUCT

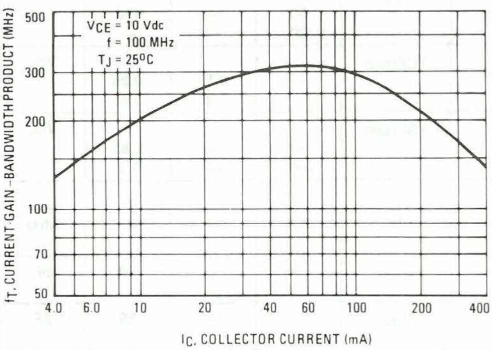


FIGURE 6 – CAPACITANCE

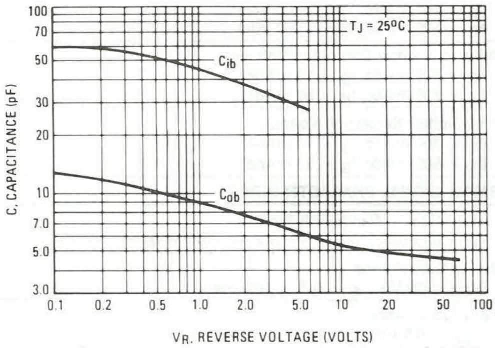


FIGURE 7 – TURN-ON TIME

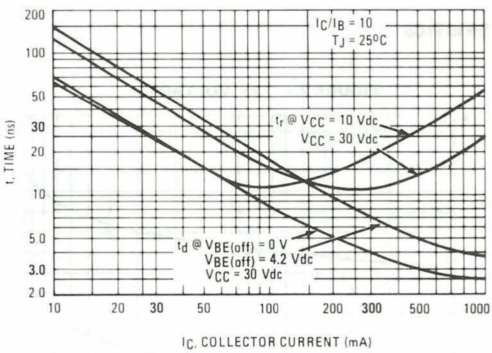


FIGURE 8 – TURN-OFF TIME

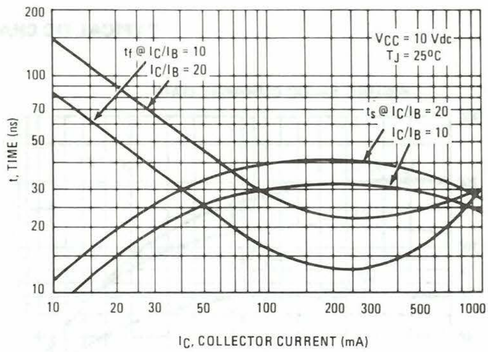


FIGURE 9 – SWITCHING TIME TEST CIRCUIT

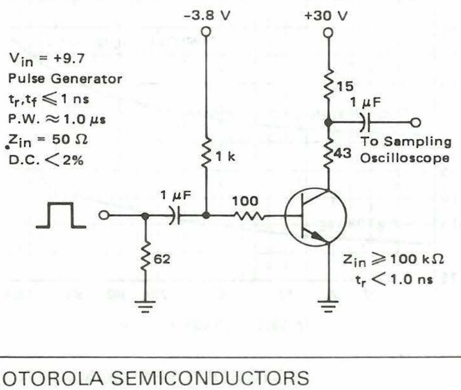
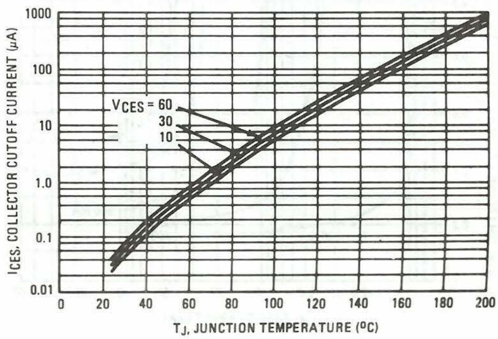


FIGURE 10 – COLLECTOR CUTOFF CURRENT



MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	1.5		Adc
		One Die	All Die Equal Power	
Total Device Dissipation @ T_A = 25°C	P_D			mW
MD3762		600	650	
MD3762F		350	400	
MQ3762		400	600	
Derate above 25°C				mW/°C
MD3762		3.42	3.7	
MD3762F		2.0	2.28	
MQ3762		2.28	3.42	
Total Device Dissipation @ T_C = 25°C	P_D			Watts
MD3762		2.1	3.0	
MD3762F		1.25	2.5	
MQ3762		1.0	4.0	
Derate above 25°C				mW/°C
MD3762		12	17.2	
MD3762F		7.15	14.3	
MQ3762		5.71	22.8	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

MD3762,F
MQ3762

MD3762
CASE 654-07, STYLE 1

MD3762F
CASE 610A-04, STYLE 1

MQ3762
CASE 607-04, STYLE 1

DUAL AMPLIFIER TRANSISTOR

PNP SILICON

THERMAL CHARACTERISTICS

Characteristic		Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case		$R_{\theta JC}$			°C/W
	MD3762		83.3	58.3	
	MD3762F		140	70	
	MQ3762		175	43.8	
Thermal Resistance, Junction to Ambient		$R_{\theta JA}$(1)			°C/W
	MD3762		292	270	
	MD3762F		500	438	
	MQ3762		438	292	
			Junction to Ambient	Junction to Case	
Coupling Factors					%
	MD3762		85	40	
	MD3762F		75	0	
	MQ3762 (Q1-Q2)		57	0	
	(Q1-Q3, Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current	I_{CBO}				
(V_{CB} = 30 Vdc, I_E = 0)		—	—	100	nAdc
(V_{CB} = 30 Vdc, I_E = 0, T_A = 100°C)		—	—	10	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	—	100	nAdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS(2)						
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)		h_{FE}	20	40	—	—
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)		$V_{CE(sat)}$	—	0.52	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)		$V_{BE(sat)}$	—	1.05	1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	150	220	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)		C_{obo}	—	8.5	20	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)		C_{ibo}	—	22	80	pF
SWITCHING CHARACTERISTICS						
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc, I_C = 1.0 Adc, I_{B1} = 100 mAdc)	t_d	—	5.0	10	ns
Rise Time		t_r	—	18	30	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 1.0 Adc, I_{B1} = I_{B2} = 100 mAdc)	t_s	—	45	80	ns
Fall Time		t_f	—	18	30	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(3) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 — DC CURRENT GAIN

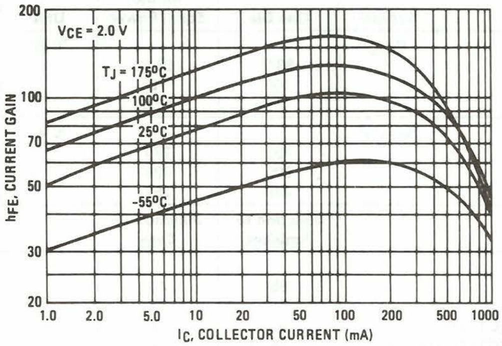


FIGURE 2 — COLLECTOR SATURATION REGION

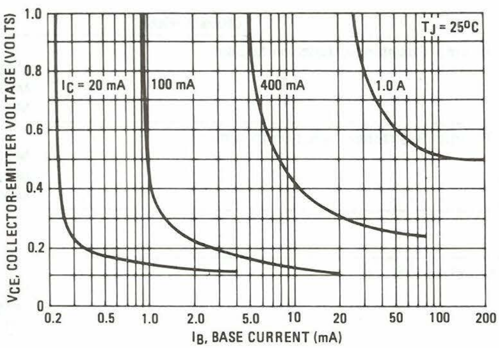


FIGURE 3 — "ON" VOLTAGE

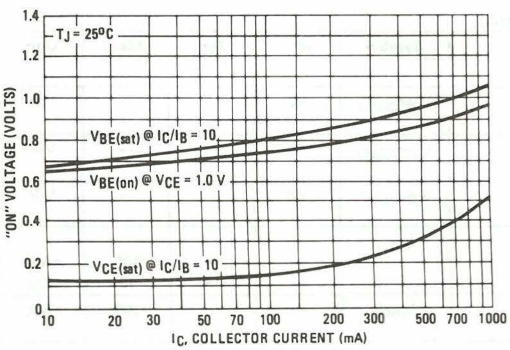


FIGURE 4 — TEMPERATURE COEFFICIENTS

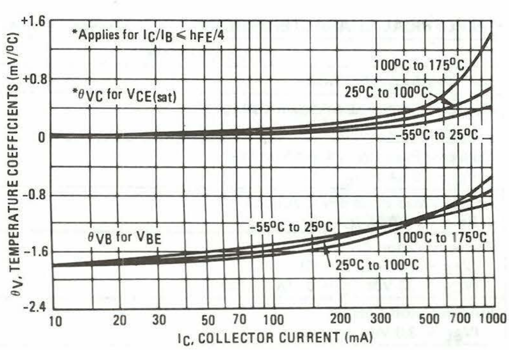


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA

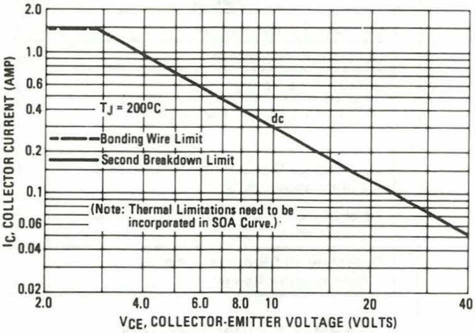


FIGURE 6 – TURN-ON TIME

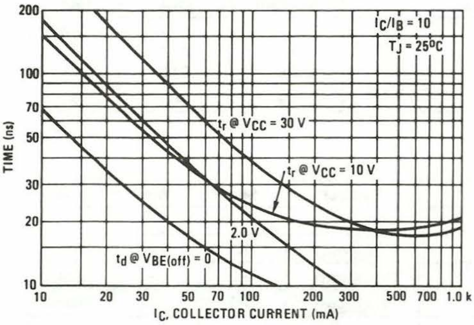


FIGURE 7 – RISE AND FALL TIME

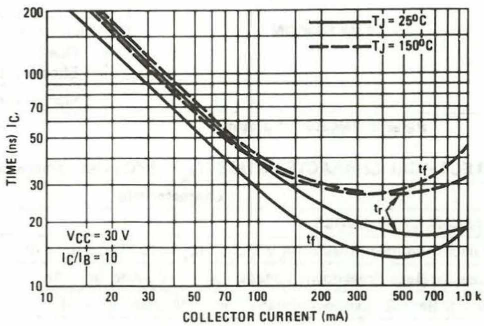


FIGURE 8 – STORAGE TIME

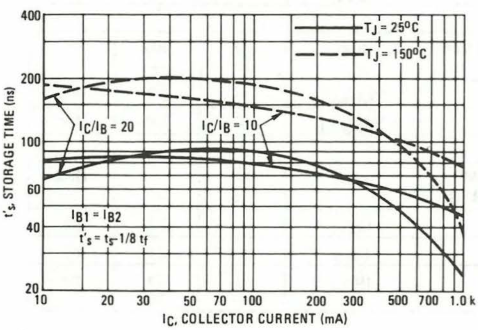


FIGURE 9 – FALL TIME

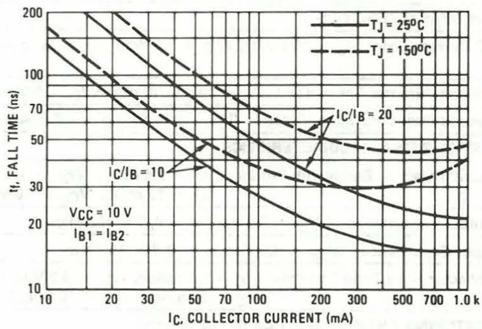


FIGURE 10 – SWITCHING TIME TEST CIRCUIT

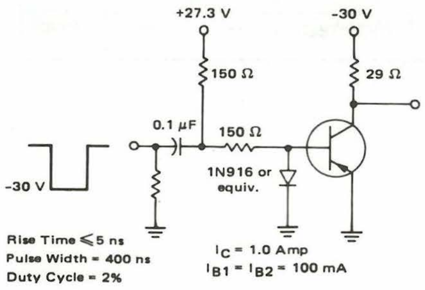
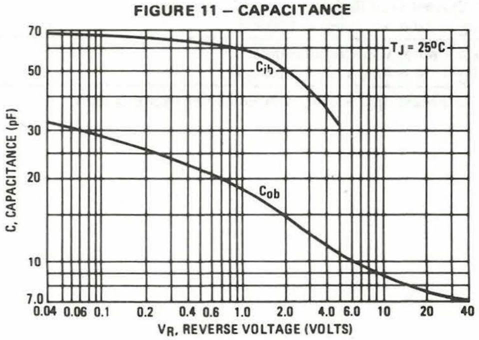


FIGURE 11 – CAPACITANCE



MD4260
MD4261

CASE 654-07, STYLE 1

DUAL
RF AMPLIFIER

PNP SILICON

5

Refer to 2N4260 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	12		Vdc
Collector-Base Voltage	V_{CBO}	12		Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		One Die	**Both Die**	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	550 3.14	600 3.42	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.4 8.0	2.0 11.4	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Junction to Ambient	Junction to Case	Unit
Thermal Resistance			°C/W
One Die	319	125	
Effective, Both Die	292	87.5	
Coupling Factor	83	40	%

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	12	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	12	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 12$ Vdc, $I_B = 0$)	I_{CEO}	—	1.0	μAdc
Collector Cutoff Current ($V_{CB} = 10$ Vdc, $I_E = 0$)	I_{CBO}	—	10	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 2.0$ Vdc)	h_{FE}	30 20	200 —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	0.3	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_C = 0.5$ mAdc, $V_{CE} = 4.0$ Vdc, f = 100 MHz) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	1.0 1.5	— —	GHz
Output Capacitance ($V_{CB} = 3.0$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	2.5	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)	C_{ibo}	—	2.5	pF
Collector Base Time Constant ($I_C = 5.0$ mAdc, $V_{CE} = 4.0$ Vdc, f = 31.8 MHz) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 31.8 MHz)	$r_b'C_c$	— —	35 30	ps
MATCHING CHARACTERISTICS (MD4261 only)				
DC Current Gain Ratio(1) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE1}/h_{FE2}	0.8	1.0	—
Base-Emitter Voltage Differential ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)	$\lvert V_{BE1} - V_{BE2} \rvert$	—	10	mVdc

(1) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

MD5000,A,B

CASE 654-07, STYLE 1

DUAL AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N3307 for graphs.

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CBO}	20		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current Continuous	I_C	50		mAdc
		One Side	Both Sides	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 1.7	400 2.3	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 3.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$) ($V_{CB} = 15$ Vdc, $I_E = 0$, $T_A = 150°C$)	I_{CBO}	— —	— —	0.010 1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 3.0$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	20	50	—	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	—	0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	—	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	600	900	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 140 kHz)	C_{obo}	—	—	1.7	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 140 kHz)	C_{ibo}	—	—	2.0	pF
Noise Figure ($I_C = 1.0$ mAdc, $V_{CE} = 6.0$ Vdc, f = 60 MHz, $R_S = 400$ ohms)	NF	—	3.0	6.0	dB
FUNCTIONAL TEST					
Amplifier Power Gain ($I_C = 6.0$ mAdc, $V_{CB} = 12$ Vdc, $R_G = R_L = 50$ ohms, f = 200 MHz)	G_{pe}	15	20	—	dB
MATCHING CHARACTERISTICS					
DC Current Gain Ratio(1) ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc) MD5000 MD5000A MD5000B	h_{FE1}/h_{FE2}	— 0.9 0.8	0.7 — —	— 1.0 1.0	—
Base-Emitter Voltage Differential ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc) MD5000 MD5000A MD5000B	$\lvert V_{BE1}-V_{BE2}\rvert$	— — —	5.0 — —	— 5.0 10	mVdc
Base-Emitter Voltage Differential Gradient ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc, $T_A = -55$ to $+125°C$) MD5000 MD5000A MD5000B	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	— — —	10 — —	— 10 20	μV/°C

(1) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

MD6001,F
MD6002,F
MD6003,F
MQ6001, MQ6002

MD6001
MD6002
MD6003

CASE 654-07, STYLE 5

MD6001F
MD6002F
MD6003F

CASE 610A-04, STYLE 1

MQ6001
MQ6002

CASE 607-04, STYLE 1

COMPLEMENTARY DUAL GENERAL PURPOSE TRANSISTOR

NPN/PNP SILICON

5

MAXIMUM RATINGS

Rating	Symbol	MD6003 MD6003F	MD6001,F MD6002,F MQ6001,2	Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CBO}	50	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		One Die	All Die Equal Power	
Total Device Dissipation @ $T_A = 25°C$	P_D			mW
MD6001,2,3		575	625	
MD6001F,2F,3F		350	400	
MQ6001,2		400	600	
Derate above 25°C				
MD6001,2,3		3.29	3.57	mW/°C
MD6001F,2F,3F		2.0	2.28	
MQ6001,2		2.28	3.42	
Total Device Dissipation @ $T_C = 25°C$	P_D			Watts
MD6001,2,3		1.8	2.5	
MD6001F,2F,3F		1.0	2.0	
MQ6001,2		0.9	3.6	
Derate above 25°C				mW/°C
MD6001,2,3		10.3	14.3	
MD6001F,2F,3F		5.71	11.4	
MQ6001,2		5.13	20.5	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic		Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case		$R_{\theta JC}$			°C/W
	MD6001,2,3		97	70	
	MD6001F,2F,3F		175	87.5	
	MQ6001,2		195	48.8	
Thermal Resistance, Junction to Ambient		$R_{\theta JA}$(1)			°C/W
	MD6001,2,3		304	280	
	MD6001F,2F,3F		500	438	
	MQ6001,2		438	292	
			Junction to Ambient	Junction to Class	
Coupling Factor					%
	MD6001,2,3		84	44	
	MD6001F,2F,3F		75	0	
	MQ6001,2 (Q1-Q2)		57	0	
	(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage		$V_{(BR)CBO}$				Vdc
($I_C = 10\ \mu$Adc, $I_E = 0$)	MD6003,F		50	—	—	
	MD6001,F, MD6002,F, MQ6001, MQ6002		60	—	—	
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Base Cutoff Current		I_{BEV}				nAdc
($V_{CE} = 30$ Vdc, $V_{BE} = 3.0$ Vdc)	MD6003,F		—	—	50	
($V_{CE} = 50$ Vdc, $V_{EB} = 3.0$ Vdc)	MD6001,F,2,F, MQ6002,F		—	—	30	

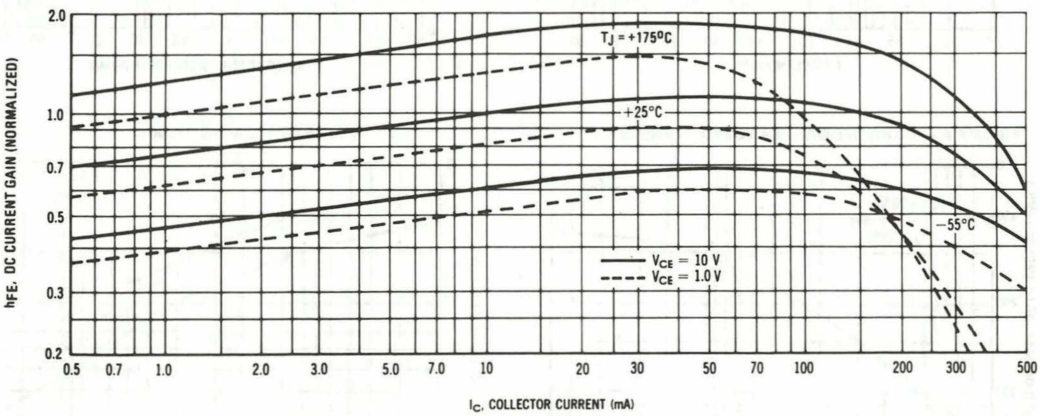
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector Cutoff Current		I_{CEV}				
(V_{CE} = 30 Vdc, $V_{BE(off)}$ = 3.0 Vdc)	MD6003,F		—	—	30	nAdc
(V_{CE} = 50 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	MD6001,F,2,F, MQ6001,2		—	—	20	nAdc
(V_{CE} = 50 Vdc, $V_{EB(off)}$ = 3.0 Vdc, T_A = 150°C)	MD6001,F,2,F, MQ6001,2		—	—	30	μAdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	MD6003,F	I_{CBO}	—	—	100	nA
ON CHARACTERISTICS(2)						
DC Current Gain		h_{FE}				—
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	MD6001,F, MQ6001		20	80	—	
	MD6002,F, MQ6002		35	70	—	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	MD6001,F, MQ6001		25	90	—	
	MD6003,F		40	70	—	
	MQ6002,F, MQ6002		50	100	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MD6001,F, MQ6001		35	70	—	
	MD6002,F, MQ6002		75	110	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MD6001,F, MQ6001		40	—	120	
	MD6003,F		70	110	—	
	MD6002,F, MQ6002		100	200	300	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)	MD6001,F, MQ6001		20	—	—	
	All Other Devices		30	90	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MD6001,F, MQ6001		20	80	—	
	MD6002,F, MQ6002		50	—	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	All Devices		—	0.3	0.4	
(I_C = 300 mAdc, I_B = 30 mAdc)	MD6001, MD6002,F, MQ6002,1		—	0.59	1.4	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	All Devices		—	1.02	1.3	
(I_C = 300 mAdc, I_B = 30 mAdc)	MD6001, MD6002,F, MQ6001,2		—	1.25	2.0	

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

5

FIGURE 1 — DC CURRENT GAIN



5

FIGURE 2 – "ON" VOLTAGES

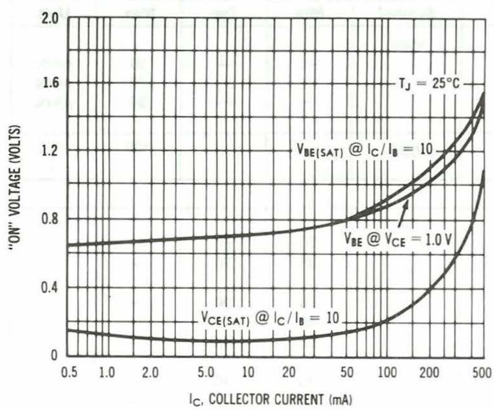
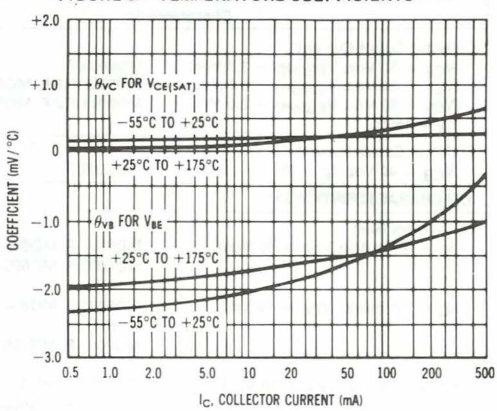


FIGURE 3 – TEMPERATURE COEFFICIENTS



NOISE FIGURE

$V_{CE} = 10$ V, $T_A = 25^oC$

FIGURE 4 – FREQUENCY EFFECTS

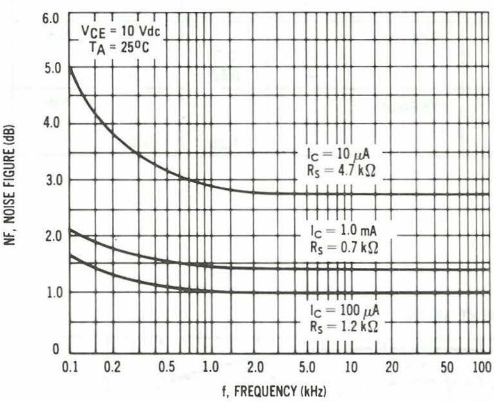


FIGURE 5 – SOURCE RESISTANCE EFFECTS

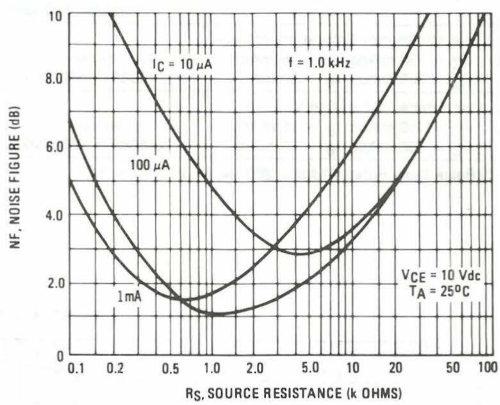


FIGURE 6 – CURRENT-GAIN BANDWIDTH PRODUCT

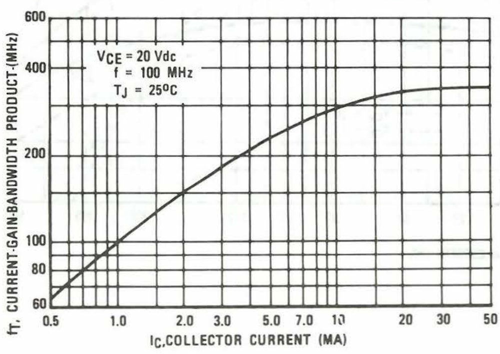


FIGURE 7 – CAPACITANCE

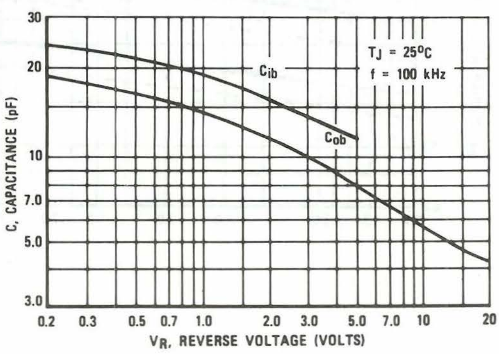


FIGURE 8 — TURN ON TIME

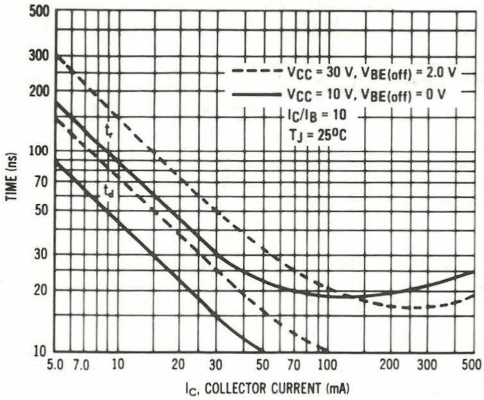


FIGURE 9 — CHARGE DATA

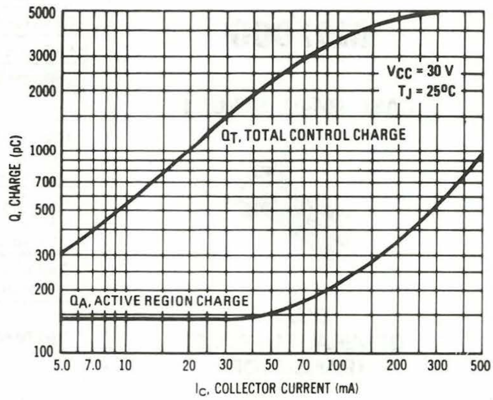


FIGURE 10 — STORAGE TIME

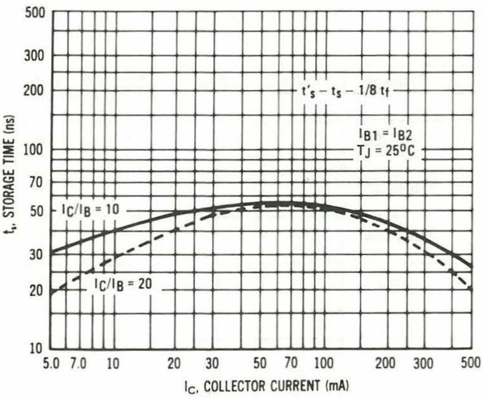


FIGURE 11 — FALL TIME

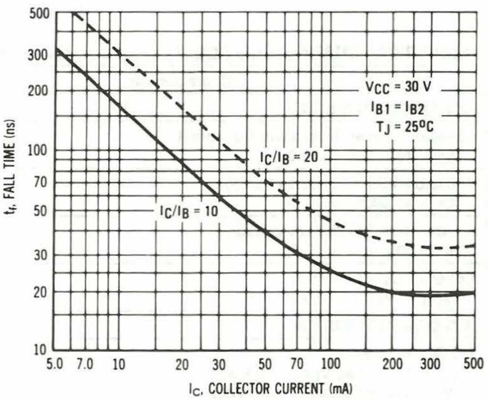


FIGURE 12 — DELAY AND RISE TIME TEST CIRCUIT

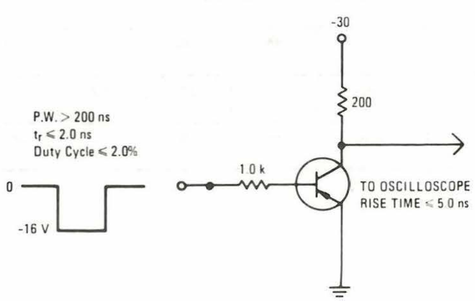
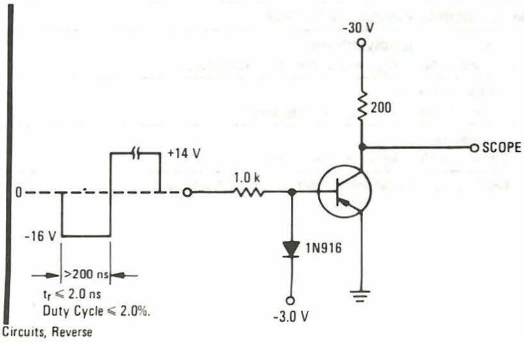


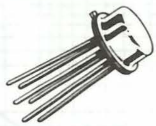
FIGURE 13 — STORAGE AND FALL TIME TEST CIRCUIT



For NPN Test Circuits, Reverse Diode and all Voltage Polarities.

MD7000

CASE 654-07, STYLE 1



DUAL GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to MD2218 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CBO}	50		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		One Die	Both Die	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	575 3.29	625 3.57	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.8 10.3	2.5 14.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	Both Die	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	70	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	304	280	°C/W
		Junction to Ambient	Junction to Case	
Coupling Factor		84	44	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	50	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 40$ Vdc, $I_E = 0$)	I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain(2) ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 300$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	 40 70 30	 60 80 50	 — — —	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{CE(sat)}$	—	0.2	0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{BE(sat)}$	—	0.95	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 20$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	200	250	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	3.5	8.0	pF
Input Capacitance ($V_{EB} = 2.0$ Vdc, $I_C = 0$, f = 100 kHz)	C_{ibo}	—	15	30	pF

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CBO}	50		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
		One Die	All Die	
Total Device Dissipation @ T_A = 25°C	P_D			mW
MD7001		600	650	
MD7001F		350	400	
MQ7001		400	600	
Derate above 25°C				mW/°C
MD7001		3.42	3.7	
MD7001F		2.0	2.28	
MQ7001		2.28	3.42	
Total Device Dissipation @ T_C = 25°C	P_D			Watts
MD7001		2.1	3.8	
MD7001F		1.25	2.5	
MQ7001		1.0	4.0	
Derate above 25°C				mW/°C
MD7001		12	17.2	
MD7001F		7.15	14.3	
MQ7001		5.71	22.8	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

MD7001,F
MQ7001

MD7001
CASE 654-07, STYLE 1

MD7001F
CASE 610A-04, STYLE 1

MQ7001
CASE 607-04, STYLE 1

DUAL
AMPLIFIER TRANSISTOR

PNP SILICON

5

THERMAL CHARACTERISTICS

Characteristic		Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case		$R_{\theta JC}$			°C/W
	MD7001		83.3	58.3	
	MD7001F		140	70	
	MQ7001		175	43.8	
Thermal Resistance, Junction to Ambient		$R_{\theta JA}$(1)			°C/W
	MD7001		292	270	
	MD7001F		500	438	
	MQ7001		438	292	
			Junction to Ambient	Junction to Case	
Coupling Factor					%
	MD7001		85	40	
	MD7001F		75	0	
	MQ7001 (Q1-Q2)		57	0	
	(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	50	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS(2)					
DC Current Gain	h_{FE}				—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		40	50	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)		70	90	—	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)		30	60	—	
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	—	0.25	0.4	Vdc

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	—	0.88	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	320	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	5.8	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	16	30	pF

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	50		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	30		mAdc
		One Die	Both Die Equal Power	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	575 3.29	625 3.57	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.8 10.3	2.5 14.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	Both Die Equal Power	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	70	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	304	280	°C/W
		Junction to Ambient	Junction to Case	
Coupling Factors		84	44	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

MD7002,A,B

CASE 654-07, STYLE 1

DUAL AMPLIFIER TRANSISTOR

NPN SILICON

5

Refer to 2N2919 for graphs.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

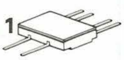
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	50	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain(2) ($I_C = 100$ μAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	40 50	130 170	— —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	0.2	0.35	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	—	0.8	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 5.0$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	200	260	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	2.6	6.0	pF
Input Capacitance ($V_{BE} = 2.0$ Vdc, $I_C = 0$, f = 100 kHz)	C_{ibo}	—	2.3	8.0	pF
MATCHING CHARACTERISTICS					
DC Current Gain Ratio(3) ($I_C = 100$ μAdc, $V_{CE} = 10$ Vdc) MD7002A MD7002B	h_{FE1}/h_{FE2}	0.75 0.85	— —	1.0 1.0	—
Base-Emitter Voltage Differential ($I_C = 100$ μAdc, $V_{CE} = 10$ Vdc) MD7002A MD7002B	$\lvert V_{BE1}-V_{BE2}\rvert$	— —	— —	25 15	mVdc

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(3) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

MD7003,A,B,F,AF
MQ7003

MD7003,A,B
CASE 654-07, STYLE 1

MD7003F,AF
CASE 610A-04, STYLE 1



MQ7003
CASE 607-04, STYLE 1

DUAL AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N3810 for curves.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	50		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		One Die	**All Die Equal Power**	
Total Device Dissipation @ $T_A = 25°C$	P_D			mW
MD7003,A,B		550	600	
MD7003F,AF		350	400	
MQ7003		400	600	
Derate above 25°C				mW/°C
MD7003,A,B		3.14	3.42	
MD7003F,AF		2.0	2.28	
MQ7003		2.28	3.42	
Total Device Dissipation @ $T_C = 25°C$	P_D			Watts
MD7003,A,B		1.4	2.0	
MD7003F,AF		0.7	1.4	
MQ7003		0.7	2.8	
Derate above 25°C				mW/°C
MD7003,A,B		8.0	11.4	
MD7003F,AF		4.0	8.0	
MQ7003		4.0	16	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD7003,A,B		125	87.5	
MD7003F,AF		250	125	
MQ7003		250	62.6	
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)			°C/W
MD7003,A,B		319	292	
MD7003F,AF		500	438	
MQ7003		438	292	
		Junction to Ambient	**Junction to Case**	
Coupling Factor				%
MD7003,A,B		83	40	
MD7003F,AF		75	0	
MQ7003 (Q1-Q2)		57	0	
(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	50	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain(2)	h_{FE}				—
($I_C = 100$ μAdc, $V_{CE} = 10$ Vdc)		40	350	—	
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)		50	350	—	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	—	0.25	0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	—	0.6	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	300	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	3.0	6.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	2.0	8.0	pF
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 kohms, f = 10 Hz to 15.7 kHz)		NF	—	2.0	—	dB
MATCHING CHARACTERISTICS						
DC Current Gain Ratio(3) (I_C = 100 μAdc, V_{CE} = 10 Vdc)	MD7003A,AF	h_{FE1}/h_{FE2}	0.75	—	1.0	—
	MD7003B		0.85	—	1.0	
Base-Emitter Voltage Differential (I_C = 100 μAdc, V_{CE} = 10 Vdc)	MD7003A,AF	$\|V_{BE1}-V_{BE2}\|$	—	—	25	mV
	MD7003B		—	—	15	

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(3) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

5

MD7007,A,B,F,BF
MQ7007

MD7007,A,B
CASE 654-07, STYLE 1

MD7007F,BF
CASE 610A-04, STYLE 1

MQ7007
CASE 607-04, STYLE 1

DUAL AMPLIFIER TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	50		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
		One Die	All Die Equal Power	
Total Device Dissipation @ $T_A = 25°C$	P_D			mW
MD7007,A,B		575	625	
MD7007F,BF		350	400	
MQ7007		400	600	
Derate above 25°C				mW/°C
MD7007,A,B		3.29	3.57	
MD7007F,BF		2.0	2.28	
MQ7007		2.28	3.42	
Total Device Dissipation @ $T_C = 25°C$	P_D			Watts
MD7007,A,B		1.8	2.5	
MD7007F,BF		1.0	2.0	
MQ7007		0.9	3.6	
Derate above 25°C				mW/°C
MD7007,A,B		10.3	14.3	
MD7007F,BF		5.71	11.4	
MQ7007		5.13	20.5	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic		Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case		$R_{\theta JC}$			°C/W
	MD7007,A,B		97	70	
	MD7007F,BF		175	87.5	
	MQ7007		195	48.8	
Thermal Resistance, Junction to Ambient		$R_{\theta JA}$(1)			°C/W
	MD7007,A,B		304	280	
	MD7007F,BF		500	438	
	MQ7007		438	292	
			Junction to Ambient	Junction to Case	
Coupling Factors					%
	MD7007,A,B		84	44	
	MD7007F,BF		75	0	
	MQ7007 (Q1-Q2)		57	0	
	(Q1-Q2 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	50	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS(2)					
DC Current Gain	h_{FE}				—
($I_C = 100$ μAdc, $V_{CE} = 10$ Vdc)		30	110	—	
($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc)		30	130	—	
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)		30	75	—	
($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc)		15	25	—	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	—	0.38	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	—	0.9	1.5	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	600	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	4.0	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	3.8	10	pF
MATCHING CHARACTERISTICS					
DC Current Gain Ratio(3) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	h_{FE1}/h_{FE2}				—
MD7007A		0.75	—	1.0	
MD7007B		0.85	—	1.0	
Base-Emitter Voltage Differential (I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	$\|V_{BE1}-V_{BE2}\|$				mVdc
MD7007A		—	—	20	
MD7007B		—	—	10	

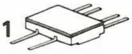
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(3) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

5

MD7021,F MQ7021

MD7021
CASE 654-07, STYLE 5

MD7021F
CASE 610A-04, STYLE 1



MQ7021
CASE 607-04, STYLE 1

COMPLEMENTARY GENERAL PURPOSE TRANSISTOR

NPN/PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	50		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		One Die	All Die Equal Power	
Total Device Dissipation @ $T_A = 25°C$	P_D			mW
MD7021		550	600	
MD7021F		350	400	
MQ7021		400	600	
Derate above 25°C				mW/°C
MD7021		3.14	3.42	
MD7021F		2.0	2.28	
MQ7021		2.28	3.42	
Total Device Dissipation @ $T_C = 25°C$	P_D			Watts
MD7021		1.4	2.0	
MD7021F		0.7	1.4	
MQ7021		0.7	2.8	
Derate above 25°C				mW/°C
MD7021		8.0	11.4	
MD7021F		4.0	8.0	
MQ7021		4.0	16	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic		Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Case		$R_{\theta JC}$			°C/W
	MD7021		125	87.5	
	MD7021F		250	125	
	MQ7021		250	62.6	
Thermal Resistance, Junction to Ambient		$R_{\theta JA}$(1)			°C/W
	MD7021		319	292	
	MD7021F		500	438	
	MQ7021		438	292	
			Junction to Ambient	Junction to Case	
Coupling Factor					%
	MD7021		83	40	
	MD7021F		75	0	
	MQ7021 (Q1-Q2)		57	0	
	(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	50	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain	h_{FE}				—
($I_C = 100\ \mu$Adc, $V_{CE} = 10$ Vdc)		40	65	—	
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)		50	70	—	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)(2)	$V_{CE(sat)}$	—	—	0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	320	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	—	6.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	—	8.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 Adc)	t_{on}	—	28	—	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_{off}	—	72	—	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MD8001
MD8002
MD8003

CASE 654-07, STYLE 1

DUAL
AMPLIFIER TRANSISTOR

NPN SILICON

5

Refer to 2N2920 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}			Vdc
MD8001		40		
MD8002		50		
MD8003		60		
Collector Current — Continuous	I_C	30		mAdc
		One Die	**Both Die Equal Power**	
Total Device Dissipation	P_D			
@ T_A = 25°C		575	625	mW
Derate above 25°C		3.29	3.57	mW/°C
Total Device Dissipation	P_D			
@ T_C = 25°C		1.8	2.5	Watts
Derate above 25°C		10.3	14.3	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die Max	Both Die Equal Power Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	70	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	304	280	°C/W
		Junction to Ambient	**Junction to Case**	
Coupling Factor		84	44	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

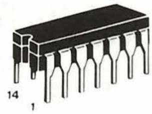
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$				Vdc
MD8001		40	—	—	
MD8002		50	—	—	
MD8003		60	—	—	
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	100	200	—	—
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	—	260	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	2.6	—	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	2.3	—	pF
MATCHING CHARACTERISTICS					
Base-Emitter Voltage Differential (I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	$\lvert V_{BE1}-V_{BE2}\rvert$	—	—	15	mVdc

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MHQ918

CASE 632-02, STYLE 1
TO-116



QUAD AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MD918 for graphs.

5

MAXIMUM RATINGS

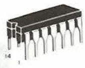
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CBO}	30		Vdc
Emitter-Base Voltage	V_{EBO}	3.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		Each Transistor	**Total Device**	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.65 3.72	1.9 10.88	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.3 7.43	4.6 26.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 3.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	10	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc) (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 — 20 —	 110 80 50	 — — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.11	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	0.84	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	600	850	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{obo}	—	0.75	2.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ibo}	—	1.4	2.5	pF
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, R_S = 400 Ohms, f = 60 MHz)	NF	—	4.0	6.0	dB

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MHQ2221
MHQ2222
MPQ2221*
MPQ2222*

MHQ2221
MHQ2222

CASE 632-02, STYLE 1
TO-116

MPQ2221
MPQ2222

CASE 646, STYLE 1

QUAD
GENERAL PURPOSE TRANSISTOR

NPN SILICON

Refer to MD2218 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		Each Transistor	**Total Device**	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C MHQ2221, MHQ2222 MPQ2221, MPQ2222	P_D	0.65 3.72 5.2	1.9 10.88 15.2	Watts mW/°C
Operating and Storage Junction Temperature Range MHQ2221,22 MPQ2221,22	T_J, T_{stg}	−65 to +200 −55 to +150		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain(1)	h_{FE}				—
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) MHQ2221, MPQ2221		35	—	—	
MHQ2222, MPQ2222		75	—	—	
($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc) MHQ2221, MPQ2221		40	—	—	
MHQ2222, MPQ2222		100	—	—	
($I_C = 300$ mAdc, $V_{CE} = 10$ Vdc) MHQ2221, MPQ2221		20	—	—	
MHQ2222, MPQ2222		30	—	—	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$				Vdc
($I_C = 150$ mAdc, $I_B = 15$ mAdc)		—	—	0.4	
($I_C = 300$ mAdc, $I_B = 30$ mAdc)		—	—	1.6	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$				Vdc
($I_C = 150$ mAdc, $I_B = 15$ mAdc)		—	—	1.3	
($I_C = 300$ mAdc, $I_B = 30$ mAdc)		—	—	2.6	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) ($I_C = 20$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	200	350	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	4.5	8.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)	C_{ibo}	—	17	30	pF
SWITCHING CHARACTERISTICS					
Turn-On Time ($V_{CC} = 30$ Vdc, $V_{BE(off)} = 0.5$ Vdc, $I_C = 150$ mAdc, $I_{B1} = 15$ mAdc)	t_{on}	—	25	—	ns
Turn-Off Time ($V_{CC} = 30$ Vdc, $I_C = 150$ mAdc, $I_{B1} = I_{B2} = 15$ mAdc)	t_{off}	—	250	—	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
*MPQ2221A and MPQ2222A also available.

FIGURE 1 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

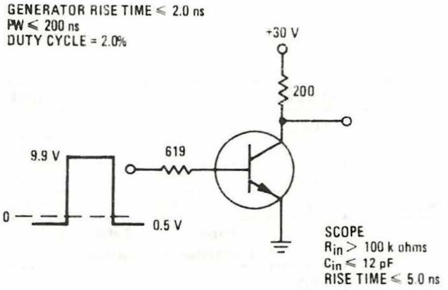
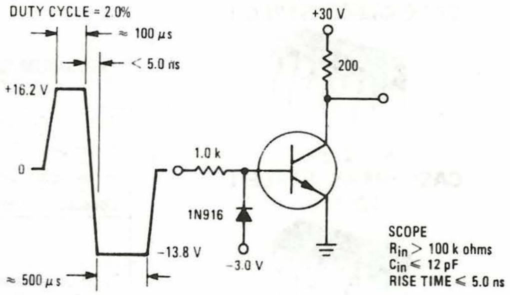


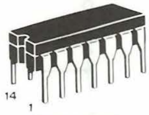
FIGURE 2 – STORAGE TIME AND FALL TIME EQUIVALENT TEST CIRCUIT



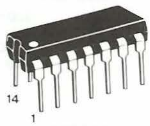
5

MHQ2369
MPQ2369

MHQ2369
CASE 632-02, STYLE 1



MPQ2369
CASE 646-05, STYLE 1
TO-116



QUAD
SWITCHING TRANSISTOR
NPN SILICON

Refer to MD2369 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	4.5		Vdc
Collector Current — Continuous	I_C	500		mAdc
		Each Transistor	**Total Device**	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C MHQ2369 MPQ2369	P_D	0.5 2.86 5.0	1.5 8.58 15	Watts mW/°C
Operating and Storage Junction Temperature Range MHQ2369 MPQ2369	T_J, T_{stg}	−65 to +200 −55 to +125		°C

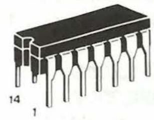
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.5	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)	I_{CBO}	—	—	0.4	μAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	0.5	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 2.0$ Vdc)	h_{FE}	40 20	— —	— —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	—	0.25	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	—	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	450	550	—	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 140 kHz)	C_{obo}	—	2.5	4.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 140 kHz)	C_{ibo}	—	3.0	5.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time ($V_{CC} = 3.0$ Vdc, $V_{BE} = 1.5$ Vdc, $I_C = 10$ mAdc, $I_{B1} = 3.0$ mAdc)	t_{on}	—	9.0	—	ns
Turn-Off Time ($V_{CC} = 3.0$ Vdc, $I_C = 10$ mAdc, $I_{B1} = 3.0$ mAdc, $I_{B2} = 1.5$ mAdc)	t_{off}	—	15	—	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.

MHQ2483
MHQ2484

CASE 632-02, STYLE 1
TO-116



QUAD
AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N2919 for graphs.

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		Each Transistor	**Total Device**	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.6 3.42	1.8 10.3	Watts mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.2 6.85	4.2 24	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)		$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 45$ Vdc, $I_E = 0$)		I_{CBO}	—	—	20	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	—	20	nAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				—
($I_C = 0.1$ mAdc, $V_{CE} = 5.0$ Vdc)	MHQ2483		100	—	—	
	MHQ2484		200	—	—	
($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)	MHQ2483		150	—	—	
	MHQ2484		300	—	—	
($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	MHQ2483		150	—	—	
	MHQ2484		300	—	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
($I_C = 1.0$ mAdc, $I_B = 0.1$ mAdc)			—	0.13	0.35	
($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)			—	0.15	0.5	
Base-Emitter On Voltage		$V_{BE(on)}$				Vdc
($I_C = 100\ \mu$Adc, $V_{CE} = 5.0$ Vdc)			—	0.58	0.7	
($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)			—	0.70	0.8	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product ($I_C = 500\ \mu$Adc, $V_{CE} = 5.0$ Vdc, f = 20 MHz)		f_T	50	100	—	MHz
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)		C_{ibo}	—	4.0	8.0	pF
Collector-Base Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 100 kHz)		C_{cb}	—	1.8	6.0	pF
Noise Figure		NF				dB
($I_C = 10\ \mu$Adc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ kohms,	MHQ2483		—	3.0	—	
f = 10 Hz to 15.7 kHz, BW = 10 kHz)	MHQ2484		—	2.0	—	

MHQ2906
MHQ2907
MPQ2906*
MPQ2907*

MHQ2906, MHQ2907
CASE 632-02, STYLE 1

MPQ2906
MPQ2907
CASE 646-05, STYLE 1
TO-116

QUAD
GENERAL PURPOSE
TRANSISTOR

PNP SILICON

Refer to MD2904 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
		Each Transistor	Total Device	
Total Device Dissipation @ $T_A = 25°C$	P_D	0.65	1.9	Watts
Derate above 25°C MHQ2906, MHQ2907		3.72	10.88	mW/°C
MPQ2906, MPQ2907		6.5	19	
Operating and Storage Junction Temperature Range MHQ2906,07	T_J, T_{stg}	−65 to +200		°C
MPQ2906,07		−55 to +125		

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)		$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)		I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current ($V_{CB} = 3.0$ Vdc, $I_E = 0$)		I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				—
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	MHQ2906, MPQ2906		35	—	—	
	MHQ2907, MPQ2907		75	—	—	
($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)	MHQ2906, MPQ2906		40	—	—	
	MHQ2907, MPQ2907		100	—	—	
($I_C = 300$ mAdc, $V_{CE} = 10$ Vdc)	MHQ2906, MPQ2906		30	—	—	
	MHQ2907, MPQ2907		50	—	—	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$				Vdc
($I_C = 150$ mAdc, $I_B = 15$ mAdc)			—	—	0.4	
($I_C = 300$ mAdc, $I_B = 30$ mAdc)			—	—	1.6	
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$				Vdc
($I_C = 150$ mAdc, $I_B = 15$ mAdc)			—	—	1.3	
($I_C = 300$ mAdc, $I_B = 30$ mAdc)			—	—	2.6	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)		f_T	200	350	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)		C_{obo}	—	6.0	8.0	pF
Input Capacitance ($V_{BE} = 2.0$ Vdc, $I_C = 0$, f = 100 kHz)		C_{ibo}	—	20	30	pF
SWITCHING CHARACTERISTICS						
Turn-On Time ($V_{CC} = 30$ Vdc, $I_C = 150$ mAdc, $I_{B1} = 15$ mAdc)		t_{on}	—	30	—	ns
Turn-Off Time ($V_{CC} = 6.0$ Vdc, $I_C = 150$ mAdc, $I_{B1} = I_{B2} = 15$ mAdc)		t_{off}	—	100	—	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.
*MPQ2906A and MPQ2907A also available.

FIGURE 1 – DELAY AND RISE TIME TEST CIRCUIT

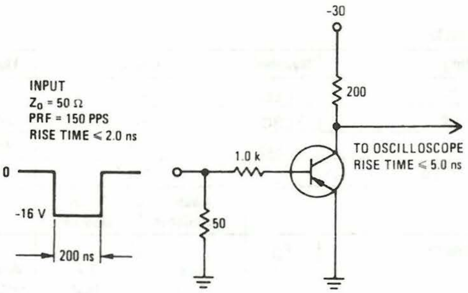
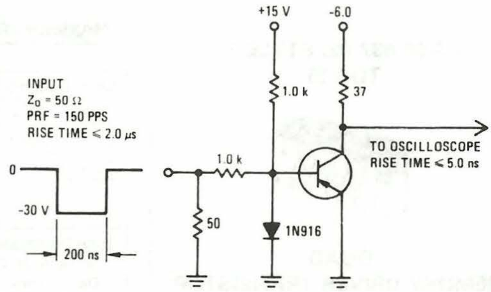
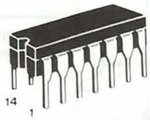


FIGURE 2 – STORAGE AND FALL TIME TEST CIRCUIT



MHQ3467

CASE 632-02, STYLE 1
TO-116



QUAD MEMORY DRIVER TRANSISTOR

PNP SILICON

Refer to MD3467 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
		Each Transistor	**Total Device**	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.9 5.14	2.7 15.4	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10.3	6.3 36	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +200		°C

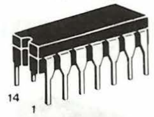
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	—	200	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	—	200	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	20	—	—	—
Collector-Emitter Saturation Voltage(1) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	—	0.23	0.5	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	—	0.9	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	125	190	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	10	25	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ibo}	—	55	80	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (I_C = 500 mAdc, I_{B1} = 50 mAdc)	t_{on}	—	—	40	ns
Turn-Off Time (I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_{off}	—	—	90	ns

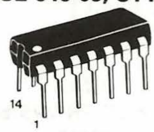
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MHQ3546
MPQ3546

MHQ3546
CASE 632-02, STYLE 1
TO-116



MPQ3546
CASE 646-05, STYLE 1



QUAD
SWITCHING TRANSISTOR
PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	12		Vdc
Collector-Base Voltage	V_{CBO}	15		Vdc
Emitter-Base Voltage	V_{EBO}	4.5		Vdc
Collector Current — Continuous	I_C	200		mAdc
		Each Transistor	Total Device	
Total Device Dissipation @ T_A = 25°C	P_D	0.5	1.5	Watts
Derate above 25°C MHQ3546		2.86	8.58	mW/°C
MPQ3546		4.0	12	
Operating and Storage Junction Temperature Range MHQ3546	T_J, T_{stg}	−65 to +200		°C
MPQ3546		−55 to +150		

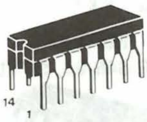
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	12	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	15	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	—	—	0.1	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	—	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain(1)	h_{FE}				—
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		30	—	—	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		15	—	—	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	600	1000	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	2.0	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	3.5	8.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 2.0 Vdc, $V_{BE(off)}$ = 3.0 Vdc, I_C = 30 mAdc, I_{B1} = 1.5 mAdc)	t_{on}	—	15	—	ns
Turn-Off Time (V_{CC} = 2.0 Vdc, I_C = 30 mAdc, I_{B1} = I_{B2} = 1.5 mAdc)	t_{off}	—	25	—	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MHQ3798
MHQ3799

CASE 632-02, STYLE 1
TO-116



QUAD
AMPLIFIER TRANSISTOR

PNP SILICON

5

Refer to 2N3810 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MHQ3798	MHQ3799	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		Each Transistor	**Total Device**	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.5 2.86	1.5 8.58	Watts mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.0 5.71	3.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

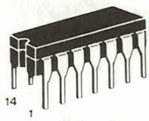
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	MHQ3798 MHQ3799	$V_{(BR)CEO}$	40 60	— —	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	—	—	10	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	—	20	nAdc
ON CHARACTERISTICS						
DC Current Gain(1) (I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	MHQ3798 MHQ3799	h_{FE}	100 225	— —	— —	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	MHQ3798 MHQ3799		150 300	— —	— —	
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)	MHQ3798 MHQ3799		150 300	— —	— —	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MHQ3798 MHQ3799		125 250	— —	— —	
Collector-Emitter Saturation Voltage (I_C = 100 μAdc, I_B = 10 μAdc) (I_C = 1.0 mAdc, I_B = 100 μAdc)		$V_{CE(sat)}$	— —	— —	0.2 0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 100 μAdc, I_B = 10 μAdc) (I_C = 1.0 mAdc, I_B = 100 μAdc)		$V_{BE(sat)}$	— —	— —	0.7 0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	—	130	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	2.3	—	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	5.5	—	pF
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 kohms, f = 10 Hz to 15.7 kHz)	MHQ3798 MHQ3799	NF	— —	2.5 1.5	— —	dB

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MHQ4001A
MHQ4002A

CASE 632-02, STYLE 1
TO-116



QUAD MEMORY DRIVER TRANSISTOR

NPN SILICON

Refer to MD3725 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MHQ4001A	MHQ4002A	Unit
Collector-Emitter Voltage	V_{CEO}	40	45	Vdc
Collector-Emitter Voltage	V_{CES}	60	70	Vdc
Collector-Base Voltage	V_{CBO}	60	70	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	1.5		Adc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	750 4.3	2500 14.3	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.2 6.86	4.0 22.8	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +200		°C

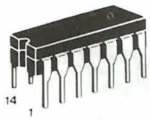
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	MHQ4001A	$V_{(BR)CEO}$	40	—	—	Vdc
	MHQ4002A		45	—	—	
Collector-Emitter Breakdown Voltage ($I_C = 10$ μAdc, $V_{BE} = 0$)	MHQ4001A	$V_{(BR)CES}$	60	—	—	Vdc
	MHQ4002A		70	—	—	
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	MHQ4001A	$V_{(BR)CBO}$	60	—	—	Vdc
	MHQ4002A		70	—	—	
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)		I_{CBO}	—	—	500	nAdc
ON CHARACTERISTICS(1)						
DC Current Gain	($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	50	100	250	—
	($I_C = 500$ mAdc, $V_{CE} = 1.0$ Vdc)		30	60	—	
	($I_C = 1.0$ Adc, $V_{CE} = 5.0$ Vdc)		20	45	—	
Collector-Emitter Saturation Voltage	($I_C = 100$ mAdc, $I_B = 10$ mAdc)	$V_{CE(sat)}$	—	0.14	0.26	Vdc
	($I_C = 500$ mAdc, $I_B = 50$ mAdc)		—	0.23	0.52	
	($I_C = 1.0$ Adc, $I_B = 100$ mAdc)		—	0.36	0.95	
Base-Emitter Saturation Voltage	($I_C = 100$ mAdc, $I_B = 10$ mAdc)	$V_{BE(sat)}$	—	0.75	0.86	Vdc
	($I_C = 500$ mAdc, $I_B = 50$ mAdc)		0.8	0.88	1.1	
	($I_C = 1.0$ Adc, $I_B = 100$ mAdc)		—	1.0	1.7	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(1) ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)		f_T	200	275	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)		C_{obo}	—	5.0	10	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)		C_{ibo}	—	55	70	pF
SWITCHING CHARACTERISTICS						
Turn-On Time ($V_{CC} = 30$ Vdc, $I_C = 0.5$ Adc, $V_{BE} = 3.8$ Vdc, $I_{B1} = 50$ mAdc)		t_{on}	—	30	40	ns
Turn-Off Time ($V_{CC} = 30$ Vdc, $I_C = 0.5$ Adc, $I_{B1} = I_{B2} = 50$ mAdc)		t_{off}	—	60	75	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MHQ4013
MHQ4014

CASE 632-02, STYLE 1
TO-116



QUAD
MEMORY DRIVER TRANSISTOR

NPN SILICON

5

Refer to MD3725 for graphs.

MAXIMUM RATINGS

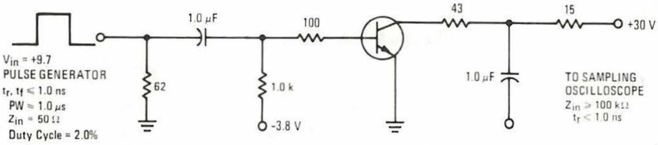
Rating	Symbol	MHQ4013	MHQ4014	Unit
Collector-Emitter Voltage	V_{CEO}	40	45	Vdc
Collector-Emitter Voltage	V_{CES}	60	70	Vdc
Collector-Base Voltage	V_{CBO}	60	70	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	1.5		Adc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	750 4.3	2500 14.3	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.2 6.86	4.0 22.8	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	MHQ4013 MHQ4014	$V_{(BR)CEO}$	40 45	— —	— —	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10$ μAdc, $V_{BE} = 0$)	MHQ4013 MHQ4014	$V_{(BR)CES}$	60 70	— —	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	MHQ4013 MHQ4014	$V_{(BR)CBO}$	60 70	— —	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$)		I_{CBO}	—	—	500	nAdc
ON CHARACTERISTICS(1)						
DC Current Gain ($I_C = 100$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 500$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 1.0$ Adc, $V_{CE} = 5.0$ Vdc)		h_{FE}	60 35 25	100 65 50	250 — —	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 10$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc) ($I_C = 1.0$ Adc, $I_B = 100$ mAdc)		$V_{CE(sat)}$	— — —	0.14 0.23 0.36	0.26 0.52 0.95	Vdc
Base-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 10$ mAdc) ($I_C = 500$ mAdc, $I_B = 50$ mAdc) ($I_C = 1.0$ Adc, $I_B = 100$ mAdc)		$V_{BE(sat)}$	— 0.8 —	0.75 0.88 1.0	0.86 1.1 1.7	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(1) ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)		f_T	200	275	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)		C_{obo}	—	5.0	10	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)		C_{ibo}	—	50	70	pF
SWITCHING CHARACTERISTICS						
Turn-On Time ($V_{CC} = 30$ Vdc, $I_C = 0.5$ Adc, $V_{BE(off)} = 3.8$ Vdc, $I_{B1} = 50$ mAdc)		t_{on}	—	20	35	ns
Turn-Off Time ($V_{CC} = 30$ Vdc, $I_C = 0.5$ Adc, $I_{B1} = I_{B2} = 50$ mAdc)		t_{off}	—	50	60	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

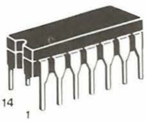
FIGURE 1 – TURN-ON AND TURN-OFF SWITCHING TIMES TEST CIRCUIT



5

MHQ6001
MHQ6002

CASE 632-02, TYPE 1
TO-116



QUAD COMPLEMENTARY TRANSISTOR

NPN/PNP SILICON

5

Refer to MHQ2222 for NPN graphs.*

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		Each Transistor	**Total Device**	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	 0.65 3.72	 1.9 10.88	 Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	 1.3 7.43	 4.6 26.3	 Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

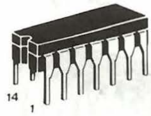
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	—	—	20	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	—	30	nAdc
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	MHQ6001 MHQ6002		25 50	— —	— —	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MHQ6001 MHQ6002		35 75	— —	 — —	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MHQ6001 MHQ6002		40 100	— —	 — —	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)	MHQ6001 MHQ6002		20 30	— —		
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc)		$V_{CE(sat)}$	— —	— —	0.4 1.4	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc)		$V_{BE(sat)}$	— —	— —	1.3 2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(1) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 kHz)		f_T	—	400	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	NPN PNP	C_{obo}	— —	6.0 4.5	— —	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)	NPN PNP	C_{ibo}	— —	20 17	— —	pF
SWITCHING CHARACTERISTICS						
Turn-On Time (V_{CC} = 30 Vdc, V_{BE} = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)		t_{on}	—	30	—	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)		t_{off}	— —	225 —	— —	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
*Refer to MHQ2907 for PNP graphs.

MHQ6100,A

CASE 632-02, TYPE 2
TO-116



QUAD COMPLEMENTARY PAIR TRANSISTOR

NPN/PNP SILICON

Refer to MHQ2483 for NPN graphs.
Refer to MHQ3798 for PNP graphs.

MAXIMUM RATINGS

Rating	Symbol	MHQ6100	MHQ6100A	Unit
Collector-Emitter Voltage	V_{CEO}	40	45	Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		Each Transistor	**Total Device**	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 2.86	1.5 8.58	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 5.71	3.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

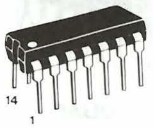
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	 MHQ6100 MHQ6100A	$V_{(BR)CEO}$	 40 45	 — —	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	—	—	10	nAdc
ON CHARACTERISTICS						
DC Current Gain(1) (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	 MHQ6100 MHQ6100A	h_{FE}	 50 100	 — —	 — —	—
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)	MHQ6100 MHQ6100A		75 150	— —	— —	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MHQ6100 MHQ6100A		75 150	— —	— —	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MHQ6100 MHQ6100A		60 125	— —	— —	
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc)		$V_{CE(sat)}$	—	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc)		$V_{BE(sat)}$	—	—	0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)	NPN PNP	f_T	— —	175 130	— —	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	NPN PNP	C_{obo}	— —	4.5 2.3	— —	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	NPN PNP	C_{ibo}	— —	6.0 5.5	— —	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPQ918

CASE 646-05, STYLE 1
TO-116



QUAD AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MD918 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CBO}	30		Vdc
Emitter-Base Voltage	V_{EBO}	3.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	500 4.0	900 7.2	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	6.7 0.825	2.4 19.2	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	151 52	250 134	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	34 2.0	70 26	% %

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 3.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 1.0$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	—	10	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 3.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	— 20 —	110 80 50	— — —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	0.11	0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	—	0.84	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	600	850	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 140 kHz)	C_{obo}	—	0.75	1.7	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 140 kHz)	C_{ibo}	—	1.1	2.0	pF
Noise Figure ($I_C = 1.0$ mAdc, $V_{CE} = 6.0$ Vdc, $R_G = 400$ Ohms, f = 60 MHz)	NF	—	4.0	6.0	dB

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	20		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	650 5.18	1250 10	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.0 8.0	3.0 24	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

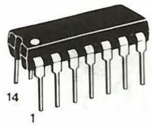
THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance(1)	Each Die	125	193	°C/W
	Effective, 4 Die	41.6	100	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	30	60	%
	Q1-Q2 or Q3-Q4	2.0	24	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

MPQ1000

CASE 646-05, STYLE 1
TO-116



QUAD AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MD2218 for graphs.

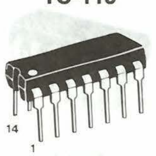
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current ($V_{EB} = 2.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS(2)					
DC Current Gain	h_{FE}				—
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)		50	—	—	
($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc)		50	—	—	
($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)		40	—	—	
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{CE(sat)}$	—	—	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{BE(sat)}$	—	—	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 20$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	175	—	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	—	8.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)	C_{ibo}	—	—	30	pF

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPQ1500

CASE 646-05, STYLE 1
TO-116



QUAD

PNP SILICON

Refer to MPQ2907 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	20		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.65 5.18	1.25 8.0	Watts mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.0 8.0	3.0 24	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Junction to Case	Junction to Ambient	Unit
Thermal Resistance(1)			°C/W
Each Die	125	193	
Effective, 4 Die	41.6	100	
Coupling Factor			%
Q1-Q4 or Q2-Q3	30	60	
Q1-Q2 or Q3-Q4	2.0	24	

(1) Junction to ambient data applies for typical printed circuit board mounting.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current ($V_{EB} = 2.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain	h_{FE}				—
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)		50	100	—	
($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc)		50	120	—	
($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)		40	80	—	
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{CE(sat)}$	—	0.22	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{BE(sat)}$	—	0.89	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(1) ($I_C = 20$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	150	300	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	4.5	8.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)	C_{ibo}	—	17	30	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPQ2221, MPQ2222

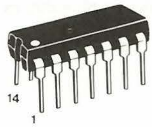
For Specifications, See MHQ2221 Data.

MPQ2369

For Specifications, See MHQ2369 Data.

MPQ2483
MPQ2484

CASE 646-05, STYLE 1
TO-116



QUAD AMPLIFIER TRANSISTOR

NPN SILICON

Refer to 2N2919 for graphs.

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		Each Transistor	**Four Transistors Equal Power**	
Total Device Dissipation @ T_A = 25°C(1) Derate above 25°C	P_D	500 4.0	900 7.2	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.825 6.7	2.4 19.2	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

(1) Second Breakdown occurs at power levels greater than 3 times the power dissipation rating.

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die	151	250	°C/W
	Effective, 4 Die	52	134	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	34	70	%
	Q1-Q2 or Q3-Q4	2.0	26	%

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)		I_{CBO}	—	—	20	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	—	20	nAdc
ON CHARACTERISTICS						
DC Current Gain(2)		h_{FE}				—
(I_C = 0.1 mAdc, V_{CE} = 5.0 Vdc)	MPQ2483		100	—	—	
	MPQ2484		200	—	—	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MPQ2483		150	—	—	
	MPQ2484		300	—	—	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MPQ2483		150	—	—	
	MPQ2484		300	—	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 1.0 mAdc, I_B = 0.1 mAdc)			—	0.13	0.35	
(I_C = 10 mAdc, I_B = 1.0 mAdc)			—	0.15	0.5	
Base-Emitter Saturation Voltage(2)		$V_{BE(sat)}$				Vdc
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)			—	0.58	0.7	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)			—	0.70	0.8	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	50	100	—	MHz
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	4.0	8.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{cb}	—	1.8	6.0	pF
Noise Figure		NF				dB
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kohms,	MPQ2483		—	3.0	—	
f = 10 Hz to 15.7 kHz, BW = 10 kHz)	MPQ2484		—	2.0	—	

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

5

MPQ2906, MPQ2907

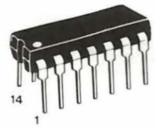
For Specifications, See MHQ2906 Data.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	12		Vdc
Collector-Base Voltage	V_{CBO}	25		Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	 650 5.2	 1250 10	 mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	 1.0 8.0	 3.0 24	 Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

MPQ3303

CASE 646-05, STYLE 1
TO-116



QUAD
SWITCHING TRANSISTOR

NPN SILICON

5

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	125 41.6	193* 100*	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	30 2.0	60 25	% %

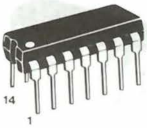
(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	12	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	25	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)	I_{CES}	—	—	100	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 0.5 Vdc) (I_C = 300 mAdc, V_{CE} = 0.5 Vdc)	h_{FE}	 30 40	 45 55	 — 200	—
Collector-Emitter Saturation Voltage (I_C = 300 mAdc, I_B = 30 mAdc) (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{CE(sat)}$	 — —	 0.22 0.52	 0.33 0.7	Vdc
Base-Emitter Saturation Voltage (I_C = 300 mAdc, I_B = 30 mAdc) (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{BE(sat)}$	 — —	 0.87 1.04	 1.1 1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	400	500	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	5.0	10	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	22	30	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 12 Vdc, I_C = 1.0 Adc, $V_{BE(off)}$ = 4.0 Vdc, I_{B1} = 100 mAdc)	t_{on}	—	12	15	ns
Turn-Off Time (V_{CC} = 12 Vdc, I_C = 1.0 Adc, I_{B1} = I_{B2} = 100 mAdc)	t_{off}	—	18	25	ns

MPQ3467

CASE 646-05, STYLE 1
TO-116



QUAD
MEMORY DRIVER TRANSISTOR

PNP SILICON

Refer to MD3467 for graphs.

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ $T_A = 25°C$(1) Derate above 25°C	P_D	650 5.2	1500 12	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.25 10	3.2 25.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

(1) Second Breakdown occurs at power levels greater than 2 times the power dissipation rating.

THERMAL CHARACTERISTICS

Characteristic		$R_{\theta JC}$ Junction to Case	$R_{\theta JA}$ Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	100 39	193 83.2	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	45 5.0	55 10	% %

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

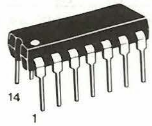
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	—	200	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	200	nAdc
ON CHARACTERISTICS					
DC Current Gain(2) ($I_C = 500$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	20	—	—	—
Collector-Emitter Saturation Voltage(2) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)	$V_{CE(sat)}$	—	0.23	0.5	Vdc
Base-Emitter Saturation Voltage(2) ($I_C = 500$ mAdc, $I_B = 50$ mAdc)	$V_{BE(sat)}$	—	0.90	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	125	190	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	10	25	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)	C_{ibo}	—	55	80	pF
SWITCHING CHARACTERISTICS					
Turn-On Time ($I_C = 500$ mAdc, $I_{B1} = 50$ mAdc)	t_{on}	—	—	40	ns
Turn-Off Time ($I_C = 500$ mAdc, $I_{B1} = I_{B2} = 50$ mAdc)	t_{off}	—	—	90	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPQ3546 For Specifications, See MHQ3546 Data.

MPQ3725,A

CASE 646-05, STYLE 1
TO-116



QUAD
CORE DRIVER TRANSISTOR

NPN SILICON

Refer to MD3725 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPQ3725	MPQ3725A	Unit
Collector-Emitter Voltage	V_{CEO}	40	50	Vdc
Collector-Emitter Voltage	V_{CES}	60	70	Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
		One Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	2.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristics	Symbol	Max		Unit
		One Transistor	Effective For Four Transistors	
Thermal Resistance, Junction to Ambient(1)	$R_{\theta JA}$	125	50	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	MPQ3725 MPQ3725A	$V_{(BR)CEO}$	40 50	— —	— —	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	MPQ3725 MPQ3725A	$V_{(BR)CES}$	60 70	— —	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)		I_{CBO}	—	—	0.5	μAdc
ON CHARACTERISTICS(2)						
DC Current Gain (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	MPQ3725 MPQ3725A	h_{FE}	35 40	75 80	200 —	—
(I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	MPQ3725 MPQ3725A		25 30	45 50	— —	
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{CE(sat)}$	—	0.32	0.45	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{BE(sat)}$	0.8	0.9	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	MPQ3725 MPQ3725A	f_T	250 200	275 250	— —	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	5.1	10	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	62	80	pF

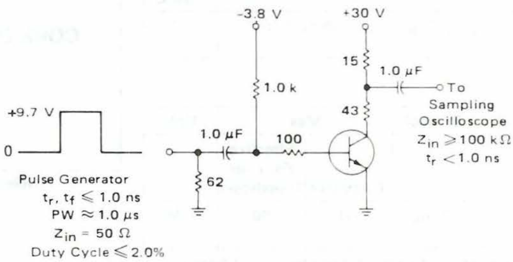
5

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
SWITCHING CHARACTERISTICS					
Turn-On Time (I_C = 500 mAdc, I_{B1} = 50 mAdc, $V_{BE(off)}$ = 3.8 Vdc)	t_{on}	—	20	35	ns
Turn-Off Time (I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_{off}	—	50	60	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	1.5		Adc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	750 5.98	1700 13.6	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.25 10	3.2 25.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

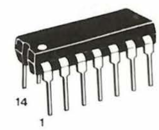
THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance(1)	Each Die	100	167	°C/W
	Effective, 4 Die	39	73.5	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	46	56	%
	Q1-Q2 or Q3-Q4	5.0	10	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

MPQ3762

CASE 646-05, STYLE 1
TO-116



QUAD
MEMORY DRIVER TRANSISTOR

PNP SILICON

Refer to MD3467 for graphs.

5

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	—	100	nAdc
Emitter Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS(2)					
DC Current Gain	h_{FE}				—
($I_C = 150$ mAdc, $V_{CE} = 1.0$ Vdc)		35	70	—	
($I_C = 500$ mAdc, $V_{CE} = 2.0$ Vdc)		30	65	—	
($I_C = 1.0$ Adc, $V_{CE} = 2.0$ Vdc)		20	35	—	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$				Vdc
($I_C = 500$ mAdc, $I_B = 50$ mAdc)		—	0.3	0.55	
($I_C = 1.0$ Adc, $I_B = 100$ mAdc)		—	0.6	0.9	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$				Vdc
($I_C = 500$ mAdc, $I_B = 50$ mAdc)		—	0.9	1.25	
($I_C = 1.0$ Adc, $I_B = 100$ mAdc)		—	1.0	1.4	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	150	275	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{obo}	—	9.0	15	pF
Input Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)	C_{ibo}	—	55	80	pF
SWITCHING CHARACTERISTICS					
Turn-On Time ($V_{CC} = 30$ Vdc, $I_C = 1.0$ Adc, $I_{B1} = 100$ mAdc, $V_{BE(off)} = 2.0$ Vdc)	t_{on}	—	—	50	ns
Turn-Off Time ($V_{CC} = 30$ Vdc, $I_C = 1.0$ Adc, $I_{B1} = I_{B2} = 100$ mAdc)	t_{off}	—	—	120	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

EQUIVALENT TEST CIRCUITS

FIGURE 1 – TURN-ON

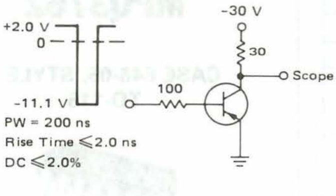
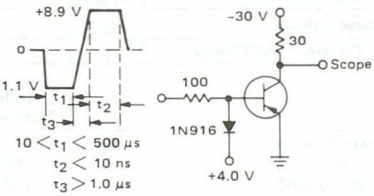


FIGURE 2 – TURN-OFF



5

MAXIMUM RATINGS

Rating	Symbol	MPQ3798	MPQ3799	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T_A = 25°C(1) Derate above 25°C	P_D	0.5 4.0	0.9 7.2	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.825 6.7	2.4 19.2	Watts m/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

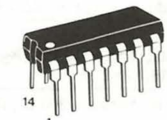
(1) Second breakdown occurs at power levels greater than 3 times the power dissipation rating.

THERMAL CHARACTERISTICS

Characteristic		$R_{\theta JC}$ Junction to Case	$R_{\theta JA}$ Junction to Ambient	Unit
Thermal Resistance	Each Die	151	250	°C/W
	Effective, 4 Die	52	139	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	34	70	%
	Q1-Q2 or Q3-Q4	2.0	26	%

MPQ3798
MPQ3799

CASE 646-05, STYLE 1
TO-116



QUAD
AMPLIFIER TRANSISTOR

PNP SILICON

Refer to 2N3810 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	MPQ3798	$V_{(BR)CEO}$	40	—	—	Vdc
	MPQ3799		60	—	—	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	—	—	10	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	—	20	nAdc
ON CHARACTERISTICS(2)						
DC Current Gain		h_{FE}			—	—
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	MPQ3798		100	—	—	
	MPQ3799		225	—		
					—	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	MPQ3798		150	—	—	
	MPQ3799		300	—		
					—	
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)	MPQ3798		150	—	—	
	MPQ3799		300	—		
					—	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MPQ3798		125	—	—	
	MPQ3799		250	—		
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 100 μAdc, I_B = 10 μAdc)			—	0.12	0.2	
(I_C = 1.0 mAdc, I_B = 100 μAdc)			—	0.07	0.25	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 100 μAdc, I_B = 10 μAdc)			—	0.62	0.7	
(I_C = 1.0 mAdc, I_B = 100 μAdc)			—	0.68	0.8	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	60	250	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	2.1	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	5.5	8.0	pF
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 kohms, f = 10 Hz to 15.7 kHz)	MPQ3798	NF	—	2.5	—	dB
	MPQ3799		—	1.5	—	

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

5

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	 500 4.0	 900 7.2	 mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	 825 6.7	 2.4 19.2	 Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	151 52	250 139	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	34 2.0	70 26	% %

MPQ3904

CASE 646-05, STYLE 1
TO-116

QUAD AMPLIFIER/SWITCHING TRANSISTOR

NPN SILICON

5

Refer to 2N3904 for graphs.

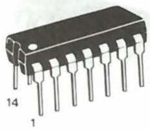
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	6.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current (V_{BE} = 40 Vdc, I_C = 0)	I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 30 50 75	 90 160 200	 — — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.1	0.2	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	0.65	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	250	300	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{obo}	—	2.0	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ibo}	—	4.0	8.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (I_C = 10 mAdc, V_{BE} = 0.5 Vdc, I_{B1} = 1.0 mAdc)	t_{on}	—	37	—	ns
Turn-Off Time (I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	t_{off}	—	136	—	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPQ3906

CASE 646-05, STYLE 1
TO-116



QUAD
AMPLIFIER/SWITCH TRANSISTOR

PNP SILICON

5

Refer to 2N3906 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	 500 4.0	 900 7.2	 mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	 825 6.7	 2.4 19.2	 Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	151 52	250 139	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	34 2.0	70 26	% %

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current ($V_{BE} = 4.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	 40 60 75	 160 180 200	 — — —	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	0.1	0.25	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	—	0.65	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	200	250	—	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 140 kHz)	C_{obo}	—	3.3	4.5	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 140 kHz)	C_{ibo}	—	4.8	10	pF
SWITCHING CHARACTERISTICS					
Turn-On Time ($I_C = 10$ mAdc, $V_{BE(off)} = 0.5$ Vdc, $I_{B1} = 1.0$ mAdc)	t_{on}	—	43	—	ns
Turn-Off Time ($I_C = 10$ mAdc, $I_{B1} = I_{B2} = 1.0$ mAdc)	t_{off}	—	155	—	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

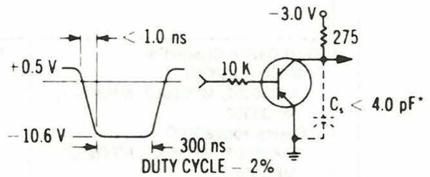
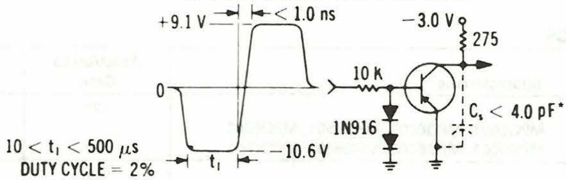


FIGURE 2 – STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT

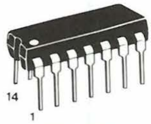


*Total shunt capacitance of test jig and connectors

5

MPQ6001
MPQ6002
TYPE 1
MPQ6501
MPQ6502
TYPE 2

CASE 646-05



QUAD COMPLEMENTARY PAIR TRANSISTOR

PNP/NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T_A = 25°C(1)	P_D			Watts
MPQ6001, MPQ6002, MPQ6501, MPQ6502		0.65	1.25	
Derate above 25°C				mW/°C
MPQ6001, MPQ6002, MPQ6501, MPQ6502		5.18	10	
Total Device Dissipation @ T_C = 25°C	P_D			Watts
MPQ6001, MPQ6002, MPQ6501, MPQ6502		1.0	3.0	
Derate above 25°C				mW/°C
MPQ6001, MPQ6002, MPQ6501, MPQ6502		8.0	24	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance		125	193	°C/W
Each Die	MPQ6001, MPQ6002, MPQ6501, MPQ6502			
Effective, 4 Die	MPQ6001, MPQ6002, MPQ6501, MPQ6502	41.6	100	
Coupling Factors		30	60	%
	MPQ6001, MPQ6002	30	60	
Q1-Q4 or Q2-Q3	MPQ6501, MPQ6502	30	60	
		30	60	
	MPQ6001, MPQ6002			
Q1-Q2 or Q3-Q4	MPQ6501, MPQ6502	20	24	
		20	24	
		20	24	
		2.0	24	

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	—	—	30	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	—	30	nAdc
ON CHARACTERISTICS						
DC Current Gain(2)		h_{FE}				—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	MPQ6001, MPQ6501		25	—	—	
	MPQ6002, MPQ6502		50	—	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MPQ6001, MPQ6501		35	—	—	
	MPQ6002, MPQ6502		75	—	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MPQ6001, MPQ6501		40	—	—	
	MPQ6002, MPQ6502		100	—	—	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)	MPQ6001, MPQ6501		20	—	—	
	MPQ6002, MPQ6502		30	—	—	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Emitter Saturation Voltage(2)		$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	—	0.4	
(I_C = 300 mAdc, I_B = 30 mAdc)			—	—	1.4	
Base-Emitter Saturation Voltage(2)		$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	—	1.3	
(I_C = 300 mAdc, I_B = 30 mAdc)			—	—	2.0	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(2) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	350	—	MHz
Output Capacitance		C_{obo}				pF
(V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	PNP		—	6.0	8.0	
	NPN		—	4.5	8.0	
Input Capacitance		C_{ibo}				pF
(V_{EB} = 2.0 Vdc, I_C = 0, f = 100 kHz)	PNP		—	20	30	
	NPN		—	17	30	
SWITCHING CHARACTERISTICS						
Turn-On Time (V_{CC} = 30 Vdc, V_{BE} = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc, Figure 1)		t_{on}	—	30	—	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)		t_{off}	—	225	—	ns

(1) Second Breakdown occurs at power levels greater than 3 times the power dissipation rating.
(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

5

NPN DATA

FIGURE 1 — NORMALIZED DC CURRENT GAIN

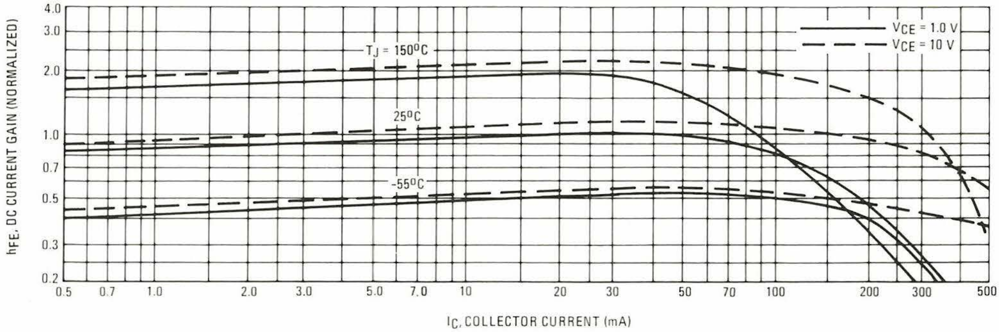


FIGURE 2 — "ON" VOLTAGES

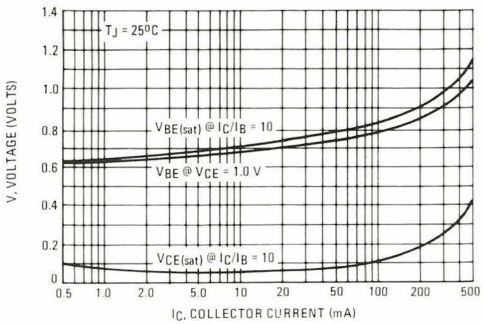
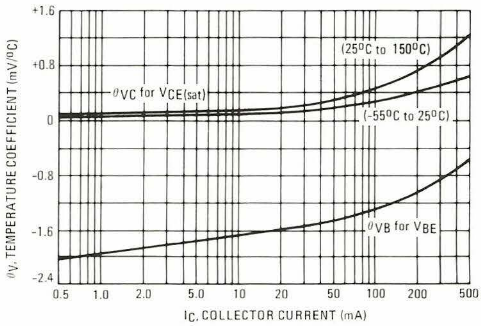


FIGURE 3 — TEMPERATURE COEFFICIENTS



NOISE FIGURE
(V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 4 — FREQUENCY EFFECTS

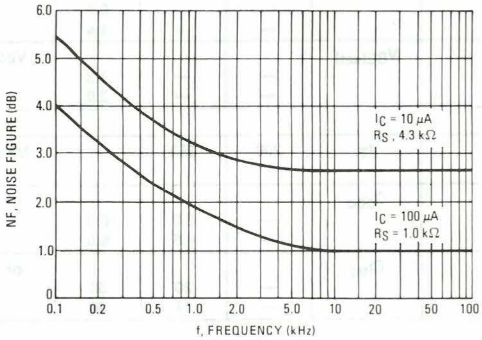
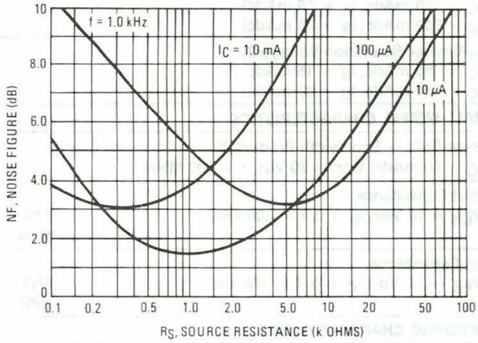


FIGURE 5 — SOURCE RESISTANCE EFFECTS

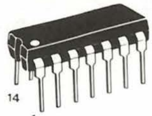


5

MPQ6100,A TYPE 1
MPQ6600,A TYPE 2

CASE 646-05

TO-116



14

1

QUAD

COMPLEMENTARY PAIR

TRANSISTOR

PNP/NPN SILICON

Refer to MHQ2483 for NPN Curves.

Refer to MHQ3798 for PNP Curves.

5

MAXIMUM RATINGS

Rating	Symbol	MPQ6100 MPQ6600	MPQ6100A MPQ6600A	Unit
Collector-Emitter Voltage	V_{CEO}	40	45	Vdc
Collector-Base Voltage	V_{CBO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	 500 4.0	 900 7.2	 mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	 0.825 6.7	 2.4 19.2	 Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance(1)	Each Die	151	250	°C/W
	Effective, 4 Die	52	139	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	34	70	%
	Q1-Q2 or Q3-Q4	2.0	26	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	 MPQ6100,6600 MPQ6100A,6600A	$V_{(BR)CEO}$	 40 45	 — —	 — —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	—	—	10	nAdc
ON CHARACTERISTICS(2)						
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	 MPQ6100,6600 MPQ6100A,6600A	h_{FE}	 50 100	 — —	 — —	—
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)	MPQ6100,6600 MPQ6100A,6600A		75 150	— —	— —	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MPQ6100,6600 MPQ6100A,6600A		75 150	— —	— —	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MPQ6100,6600 MPQ6100A,6600A		60 125	— —	— —	
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 100 μAdc)		$V_{CE(sat)}$	—	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 100 μAdc)		$V_{BE(sat)}$	—	—	0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	50	—	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	 PNP NPN	C_{obo}	 — —	 1.2 1.8	 4.0 4.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	PNP	C_{ibo}	—	—	8.0	pF
	NPN		—	—	8.0	
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kohms, f = 10 Hz to 15.7 kHz, BW = 10 kHz)		NF	—	4.0	—	dB

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

5

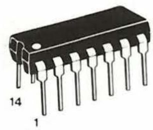
MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage MPQ6426 MPQ6427	V_{CEO}	 30 40		Vdc
Collector-Base Voltage MPQ6426 MPQ6427	V_{CBO}	 40 50		Vdc
Emitter-Base Voltage	V_{EBO}	12		Vdc
Collector Current — Continuous	I_C	500		mAdc
		Each Die	Four Die Equal Power	
Total Device Dissipation @ T_A = 25°C(1) Derate above 25°C	P_D	 500 4.0	 900 7.2	 mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	 825 6.7	 2400 19.2	 mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

(1) Second Breakdown occurs at power levels greater than 3 times the power dissipation rating.

MPQ6426
MPQ6427

CASE 646-05, STYLE 1
TO-116



QUAD
DARLINGTON TRANSISTOR

NPN SILICON

5

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	151 52	250 139	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	34 2.0	70 26	% %

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	 MPQ6426 MPQ6427	$V_{(BR)CEO}$	 30 40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	 MPQ6426 MPQ6427	$V_{(BR)CBO}$	 40 50	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		$V_{(BR)EBO}$	12	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	—	100	nAdc
Emitter Cutoff Current (V_{BE} = 10 Vdc, I_C = 0)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS(2)					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)		h_{FE}	 5000 10,000	 — —	—
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 0.1 mAdc)		$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	—	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	125	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{obo}	—	8.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ibo}	—	15	pF

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

NOISE CHARACTERISTICS
(V_{CE} = 5.0 Vdc, T_A = 25°C)

FIGURE 1 – NOISE VOLTAGE

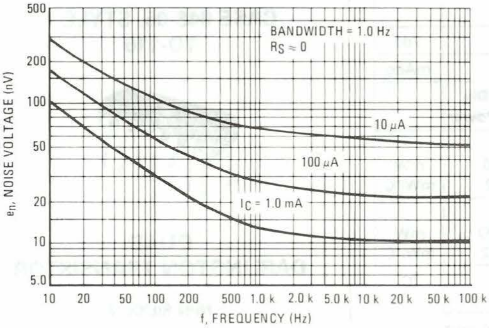


FIGURE 2 – NOISE CURRENT

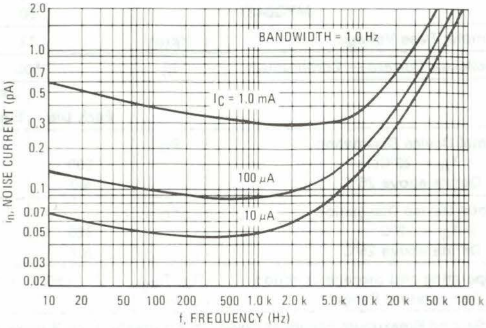


FIGURE 3 – TOTAL WIDEBAND NOISE VOLTAGE

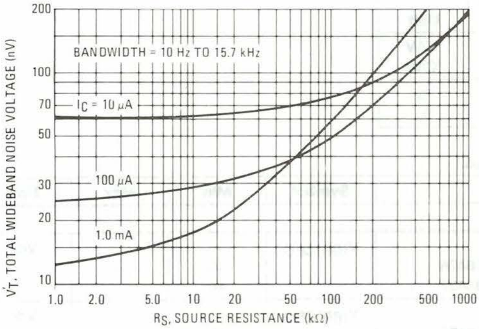
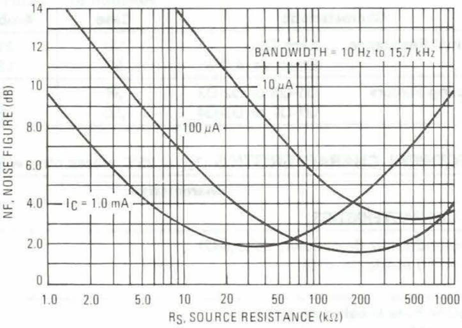


FIGURE 4 – WIDEBAND NOISE FIGURE



DYNAMIC CHARACTERISTICS

FIGURE 5 – CAPACITANCE

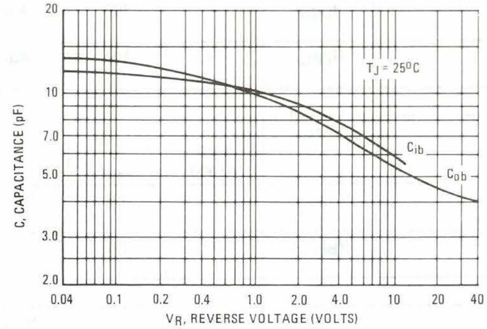
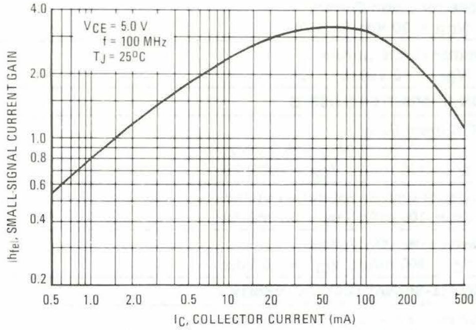
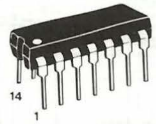


FIGURE 6 – HIGH FREQUENCY CURRENT GAIN



MPQ6700

CASE 646-05, TYPE 2
TO-116



QUAD COMPLEMENTARY PAIR TRANSISTOR

PNP/NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CBO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T_A = 25°C(1) Derate above 25°C	P_D	 500 4.0	 900 7.2	 mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	 825 6.7	 2400 19.2	 mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

(1) Second breakdown occurs at power levels greater than 3 times the power dissipation rating.

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	151 52	250 139	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	34 2.0	70 26	% %

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	50	nAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	50	nAdc
ON CHARACTERISTICS(2)				
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 30 50 70	 — — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(2) (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	4.5	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz) PNP NPN	C_{ibo}	 — —	 10 8.0	pF

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

5

NPN PNP

FIGURE 1 – DC CURRENT GAIN

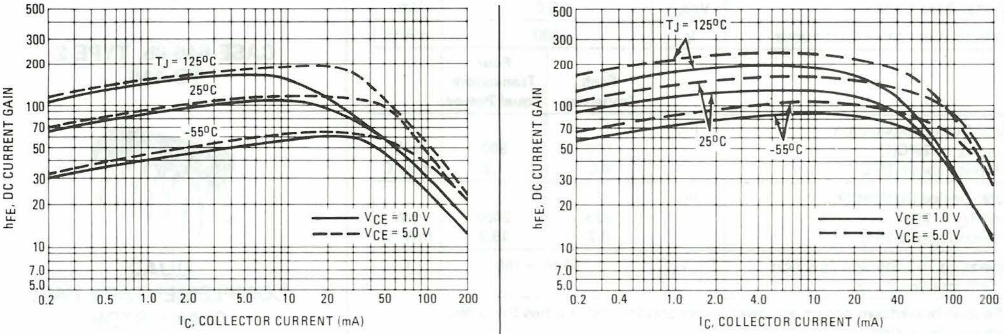


FIGURE 2 – "ON" VOLTAGE

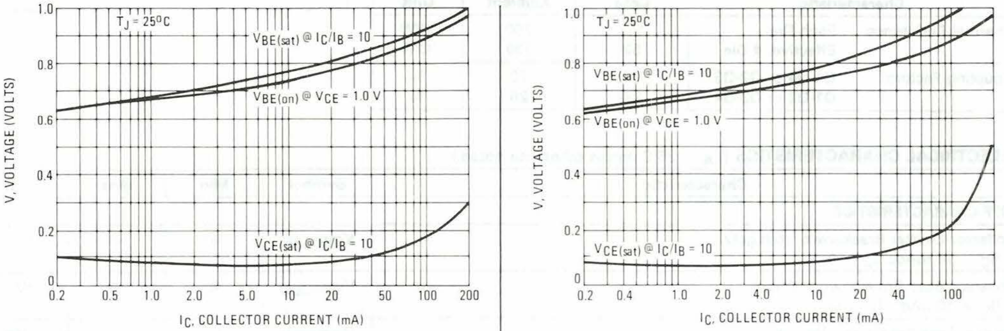
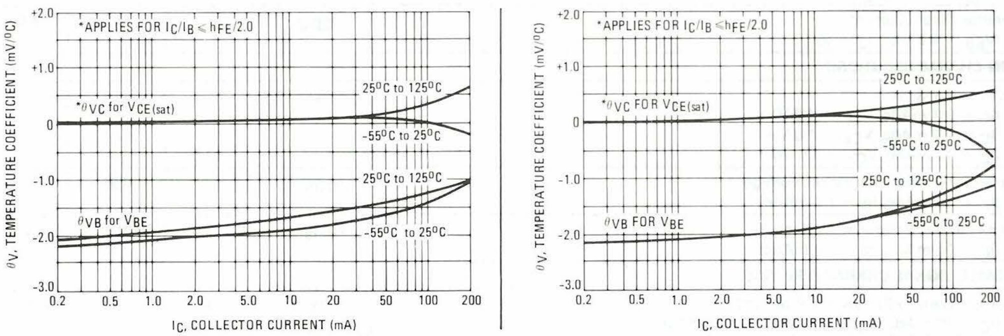


FIGURE 3 – TEMPERATURE COEFFICIENTS



NPN | PNP

FIGURE 4 — COLLECTOR SATURATION REGION

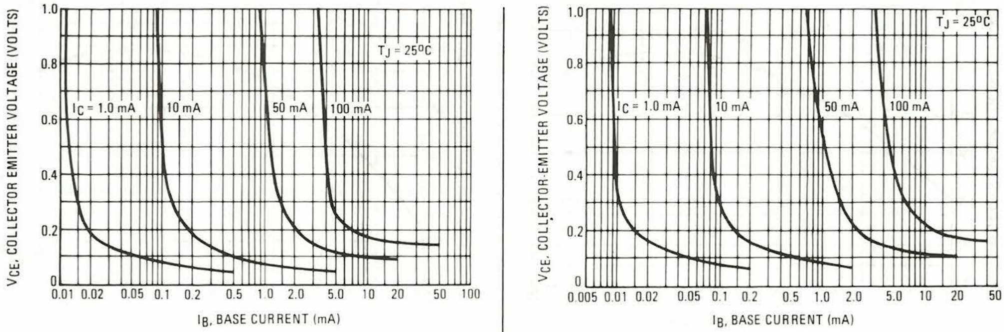


FIGURE 5 — TURN-ON TIME

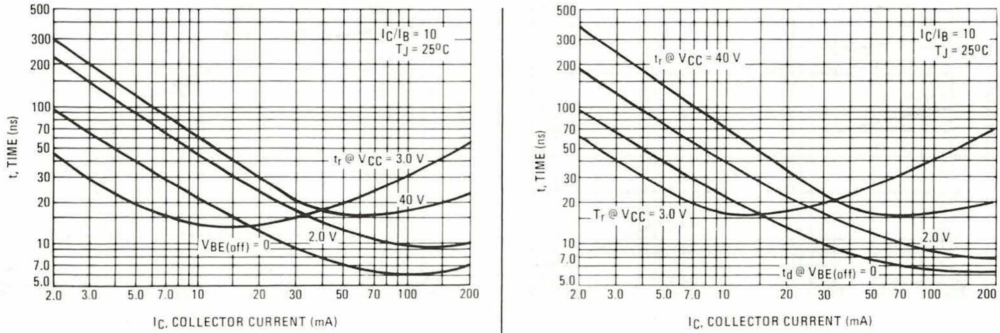
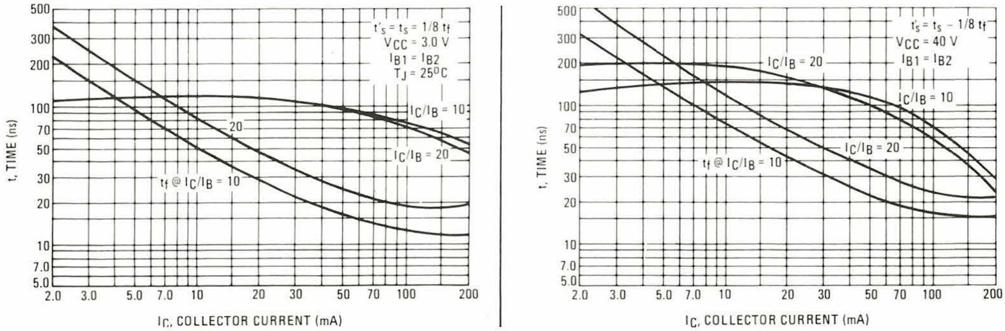
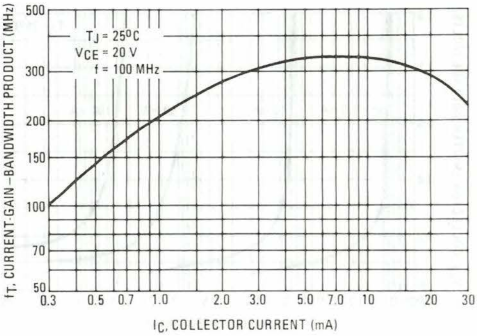


FIGURE 6 — TURN-OFF TIME



NPN PNP

FIGURE 7 — CURRENT-GAIN — BANDWIDTH PRODUCT



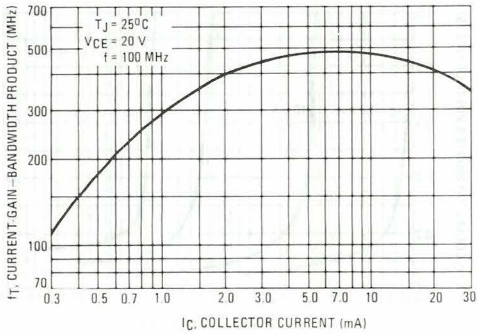
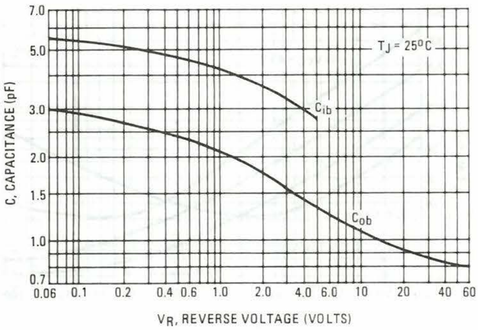
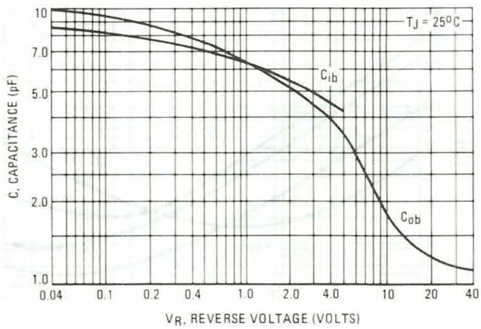


FIGURE 8 — CAPACITANCE





MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CBO}	30		Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Device Dissipation @ T_A = 25°C(1) Derate above 25°C	P_D	500 4.0	900 7.2	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	825 6.7	2400 19.2	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

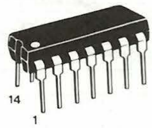
(1) Second Breakdown occurs at power levels greater than 3 times the power dissipation rating.

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	151 52	250 139	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	34 2.0	70 26	% %

MPQ6842

CASE 646-05, TYPE 2
TO-116



QUAD COMPLEMENTARY PAIR TRANSISTOR

PNP/NPN SILICON

5

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS(2)					
DC Current Gain (I_C = 0.5 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	30 50 70	— — —	— — —	—
Collector-Emitter Saturation Voltage (I_C = 0.5 mAdc, I_B = 0.05 mAdc, 0°C ≤ T ≤ 70°C)	$V_{CE(sat)}$	—	0.05	0.15	Vdc
Base-Emitter Saturation Voltage (I_C = 0.5 mAdc, I_B = 0.05 mAdc)	$V_{BE(sat)}$	—	0.65	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product(2) (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	350	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	3.0	4.5	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz) PNP NPN	C_{ibo}	— —	5.0 4.0	10 8.0	pF
SWITCHING CHARACTERISTICS (T_A = 25°C, V_{CC} = 5.0 Vdc)					
Propagation Delay Time (50% Points TP1 to TP3) (50% Points TP2 to TP4)	 t_{PLH} t_{PHL}	 — —	 15 6.0	 25 15	ns
Rise Time (0.3 V to 4.7 V, TP3 or TP4)	t_r	5.0	25	35	ns
Fall Time (4.7 V to 0.3 V, TP3 or TP4)	t_f	5.0	10	20	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

5

NPN | PNP

FIGURE 1 — DC CURRENT GAIN

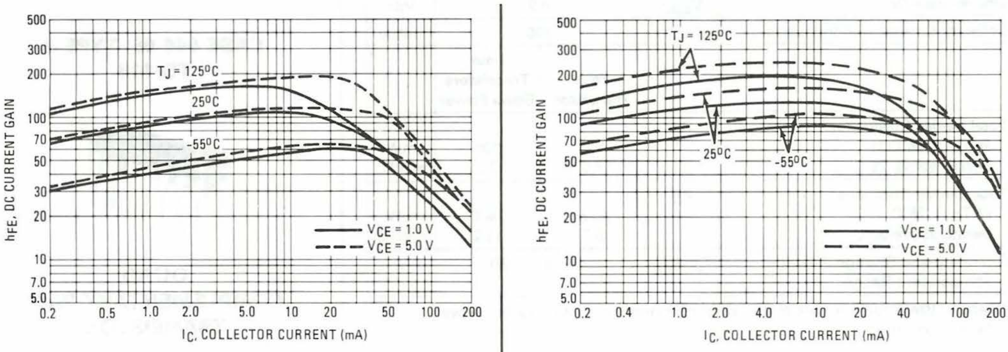


FIGURE 2 — "ON" VOLTAGE

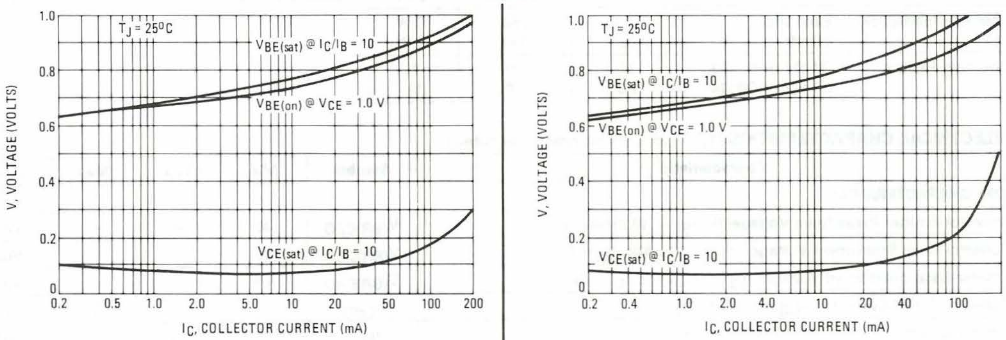
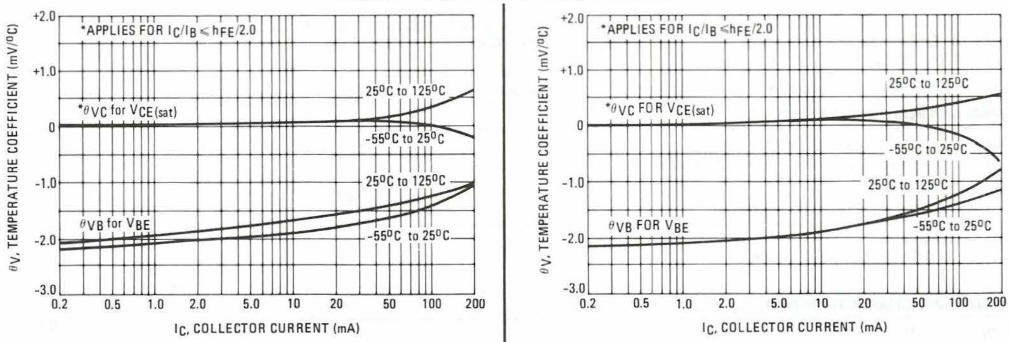


FIGURE 3 — TEMPERATURE COEFFICIENTS



NPN PNP

FIGURE 4 – COLLECTOR SATURATION REGION

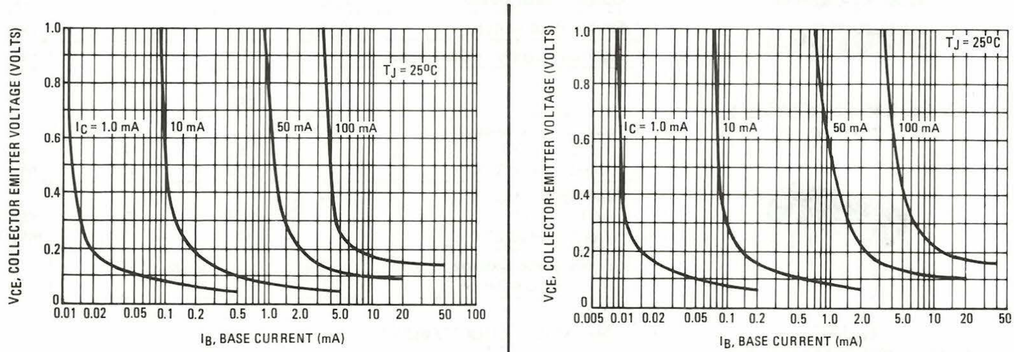
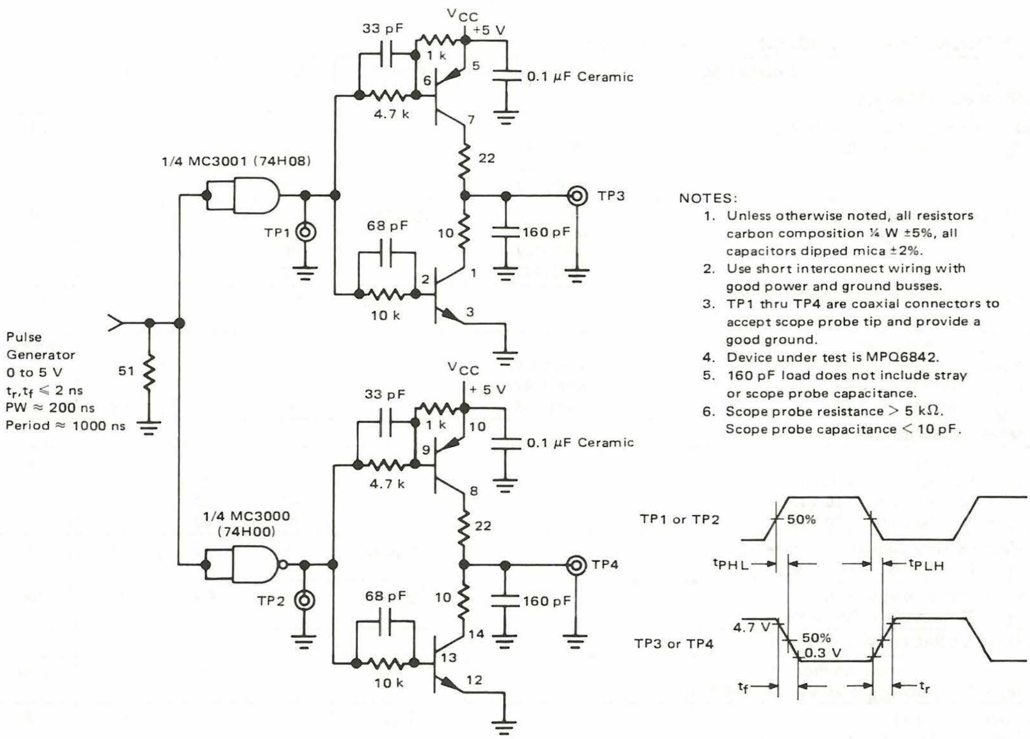


FIGURE 5 – SWITCHING TIMES TEST CIRCUIT AND WAVEFORMS

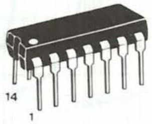


NOTES:

1. Unless otherwise noted, all resistors carbon composition ¼ W ±5%, all capacitors dipped mica ±2%.
2. Use short interconnect wiring with good power and ground busses.
3. TP1 thru TP4 are coaxial connectors to accept scope probe tip and provide a good ground.
4. Device under test is MPQ6842.
5. 160 pF load does not include stray or scope probe capacitance.
6. Scope probe resistance > 5 kΩ. Scope probe capacitance < 10 pF.

MPQ7041
MPQ7042
MPQ7043

CASE 646-05, STYLE 1
TO-116



QUAD AMPLIFIER TRANSISTOR

NPN SILICON

Refer to MPQ7051 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPQ7041	MPQ7042	MPQ7043	Unit
Collector-Emitter Voltage	V_{CEO}	150	200	250	Vdc
Collector-Base Voltage	V_{CBO}	150	200	250	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current — Continuous	I_C	500			mAdc
		Each Die	Four Die Equal Power		
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	750 5.98	1700 13.6		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.25 10	3.2 25.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die	100	167	°C/W
	Effective, 4 Die	39	73.5	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	46	56	%
	Q1-Q2 or Q3-Q4	5.0	10	%

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	MPQ7041	$V_{(BR)CEO}$	150	—	—	Vdc
	MPQ7042		200	—	—	
	MPQ7043		250	—	—	
Collector-Base Breakdown Voltage ($I_C = 100$ µAdc, $I_E = 0$)	MPQ7041	$V_{(BR)CBO}$	150	—	—	Vdc
	MPQ7042		200	—	—	
	MPQ7043		250	—	—	
Emitter-Base Breakdown Voltage ($I_E = 100$ µAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 120$ Vdc, $I_E = 0$)	MPQ7041	I_{CBO}	—	—	100	nAdc
($V_{CB} = 150$ Vdc, $I_E = 0$)	MPQ7042		—	—	100	
($V_{CB} = 180$ Vdc, $I_E = 0$)	MPQ7043		—	—	100	
ON CHARACTERISTICS						
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc)		h_{FE}	25	45	—	—
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)			40	60	—	
($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)			40	80	—	
Collector-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		$V_{CE(sat)}$	—	0.3	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		$V_{BE(sat)}$	—	0.7	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)		f_T	50	80	—	MHz
Output Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	2.5	5.0	pF
Input Capacitance ($V_{EB} = 3.0$ Vdc, $I_C = 0$, f = 1.0 MHz)		C_{ibo}	—	40	50	pF

MAXIMUM RATINGS

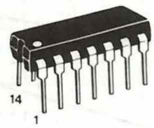
Rating	Symbol	MPQ7051	MPQ7052	MPQ7053	Unit
Collector-Emitter Voltage	V_{CEO}	150	200	250	Vdc
Collector-Base Voltage	V_{CBO}	150	200	250	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current — Continuous	I_C	500			mAdc
		Each Die	Four Die Equal Power		
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	750 5.98	1700 13.6		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.25 10	3.2 25.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	100 39	167 73.5	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	46 5.0	56 10	% %

MPQ7051
MPQ7052
MPQ7053

CASE 646-05, TYPE 2
TO-116



QUAD COMPLIMENTARY PAIR TRANSISTOR

NPN/PNP SILICON

5

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	MPQ7051 MPQ7052 MPQ7053	$V_{(BR)CEO}$	150 200 250	— — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	MPQ7051 MPQ7052 MPQ7053	$V_{(BR)CBO}$	150 200 250	— — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 120$ Vdc, $I_E = 0$) ($V_{CB} = 150$ Vdc, $I_E = 0$) ($V_{CB} = 180$ Vdc, $I_E = 0$)	MPQ7051 MPQ7052 MPQ7053	I_{CBO}	— — —	250 250 250	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)		h_{FE}	25 35 25	— — —	—
Collector-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		$V_{CE(sat)}$	—	0.7	Vdc
Base-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)		f_T	50	—	MHz
Output Capacitance ($V_{CB} = 20$ Vdc, $I_C = 0$, f = 1.0 MHz)		C_{obo}	—	6.0	pF
Input Capacitance ($V_{EB} = 3.0$ Vdc, $I_C = 0$, f = 1.0 MHz)	NPN PNP	C_{ibo}	— —	50 75	pF

DC CHARACTERISTICS

NPN | PNP

FIGURE 1 – DC CURRENT GAIN

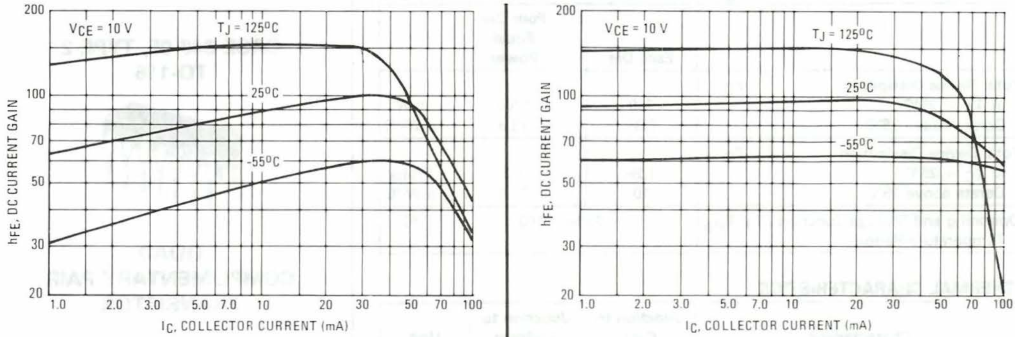


FIGURE 2 – "ON" VOLTAGES

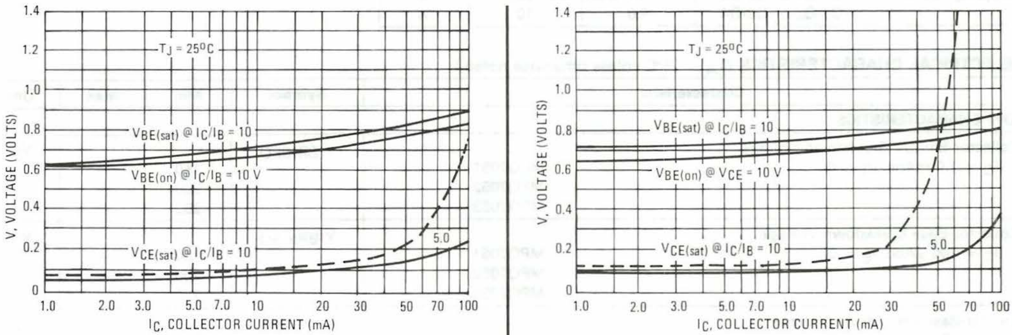
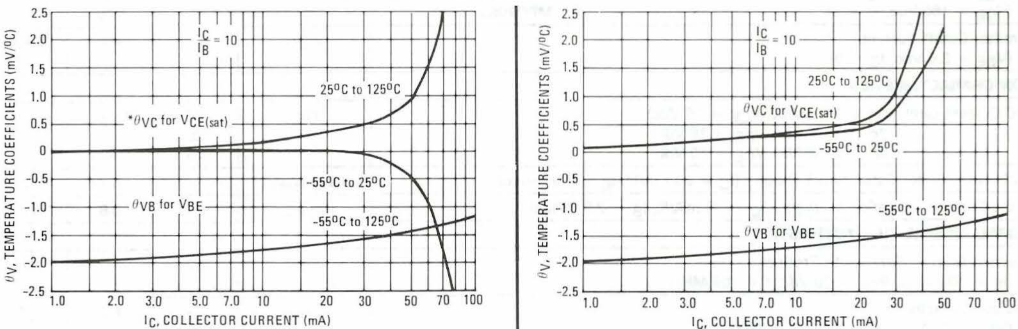
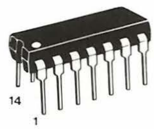


FIGURE 3 – TEMPERATURE COEFFICIENTS



MPQ7091
MPQ7092
MPQ7093

CASE 646-05, STYLE 1
TO-116



QUAD AMPLIFIER TRANSISTOR

PNP SILICON

Refer to MPQ7051 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPQ7091	MPQ7092	MPQ7093	Unit
Collector-Emitter Voltage	V_{CEO}	150	200	250	Vdc
Collector-Base Voltage	V_{CBO}	150	200	250	Vdc
Emitter-Base Voltage	V_{EBO}	5.0			Vdc
Collector Current — Continuous	I_C	500			mAdc
		Each Die	Four Die Equal Power		
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	750 5.98	1700 13.6		mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.25 10	3.2 25.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150			°C

THERMAL CHARACTERISTICS

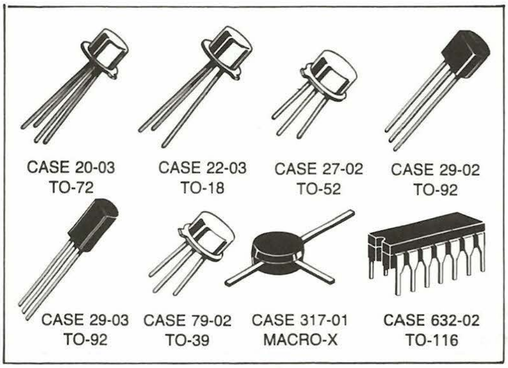
Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die	100	167	°C/W
	Effective, 4 Die	39	73.5	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	46	56	%
	Q1-Q2 or Q3-Q4	5.0	10	%

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	MPQ7091 MPQ7092 MPQ7093	$V_{(BR)CEO}$	150 200 250	— — —	— — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	MPQ7091 MPQ7092 MPQ7093	$V_{(BR)CBO}$	150 200 250	— — —	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 120$ Vdc, $I_E = 0$) ($V_{CB} = 150$ Vdc, $I_E = 0$) ($V_{CB} = 180$ Vdc, $I_E = 0$)	MPQ7091 MPQ7092 MPQ7093	I_{CBO}	— — —	— — —	250 250 250	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)		h_{FE}	25 35 25	40 55 50	— — —	—
Collector-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		$V_{CE(sat)}$	—	0.3	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)		$V_{BE(sat)}$	—	0.7	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)		f_T	50	70	—	MHz
Output Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	3.0	5.0	pF
Input Capacitance ($V_{EB} = 3.0$ Vdc, $I_C = 0$, f = 1.0 MHz)		C_{ibo}	—	60	75	pF

MQ982

For Specifications, See MD982 Data.



The data sheets on the following pages are designed to emphasize those FET's that by virtue of widespread industry use, ease of manufacture, and consequently low relative cost, merit first consideration for new equipment design. Package options from low-cost plastic to metal packages are available.

CAUTION:

Static electricity is a surface phenomenon which most commonly occurs when two dissimilar materials come into contact and then separate. Electro Static Discharge (ESD) damage of semiconductor components by operating personnel is quickly becoming a very prominent and significant problem. From simple bipolar designs to sensitive MOSFET structures, ESD has its unforgiving effect of degradation or destruction.

Motorola believes it is important to extend an emphasizing note of cautiousness when handling and testing *ANY* FET product. Precautions include, but are not limited to, the implementation of static safe workstations and proper handling techniques (see below). Additionally, it is very important to keep FET devices in their antistatic shipping containers and away from any static-generating materials.

HANDLING CONSIDERATIONS:

MOS Field-Effect Transistors, due to their extremely high input resistance, are subject to potential damage by the accumulation of excess static charge. To avoid possible damage to the devices while handling, testing, or in actual operation, the following procedure should be followed:

1. The leads of the devices should remain wrapped in the shorting spring except when being tested or in actual operation to avoid the build-up of static charge.
2. Avoid unnecessary handling; when handled, the devices should be picked up by the *can* instead of the leads.
3. The devices should not be inserted or removed from circuits with the power on as transient voltages may cause permanent damage to the devices.

Field-Effect Transistors

6

2N2608
2N2609

CASE 22-03, STYLE 12
TO-18 (TO-206AA)

JFET
GENERAL PURPOSE

P-CHANNEL — DEPLETION

Refer to 2N5460 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Gate Current	I_G	50	mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 1.7	mW mW/°C
Storage Temperature Range	T_{stg}	−60 to +200°C	°C

6

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = 1.0\ \mu A$)		$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current ($V_{GS} = 5.0$ V)		I_{GSS}	—	10	nA
Gate Source Cutoff Voltage ($V_{DS} = -5.0$ V, $I_D = -1.0\ \mu A$)		$V_{GS(off)}$	1.0	4.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current ($V_{DS} = -5.0$ V, $V_{GS} = 0$ V)	2N2608 2N2609	I_{DSS}*	−0.9 −2.0	−4.5 −10.0	mA
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance ($V_{DS} = -5.0$ V, f = 1.0 kHz)	2N2608 2N2609	$\|y_{fs}\|$*	1000 2500	— —	μmhos
Input Capacitance ($V_{DS} = -5.0$ V, $V_{GS} = 1.0$ V, f = 140 kHz)	2N2608 2N2609	C_{iss}	— —	17 30	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure ($V_{DS} = -5.0$ V, f = 1.0 kHz, R = 1.0 meg)		NF	—	3.0	dB

*Pulse Width ≤ 100 msec., Duty Cycle ≤ 10%.

2N2843
2N2844

CASE 22-03, STYLE 22
TO-18 (TO-206AA)

JFET
GENERAL PURPOSE

P-CHANNEL — DEPLETION

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Drain Current	I_D	50	mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 1.7	mW mW/°C
Storage Temperature Range	T_{stg}	−60 to +200°C	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = 1.0\ \mu A$)		$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current ($V_{GS} = 5.0$ V)		I_{GSS}	—	10	nA
Gate Source Cutoff Voltage ($V_{DS} = -5.0$ V, $I_D = -1.0\ \mu A$)		$V_{GS(off)}$	—	1.7	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current ($V_{DS} = -5.0$ V)	 2N2843 2N2844	I_{DSS}*	 200 440	 1000 2200	μA
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance ($V_{DS} = -5.0$ V, f = 1.0 kHz)	 2N2843 2N2844	$\|y_{fs}\|$*	 540 1400	 — —	μmhos
Input Capacitance ($V_{DS} = -5.0$ V, $V_{GS} = 1.0$ V, f = 140 kHz)	 2N2843 2N2844	C_{iss}	 — —	 17 30	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure ($V_{DS} = -5.0$ V, f = 1.0 kHz, $R_G = 1.0$ meg)		NF	—	3.0	dB

*Pulse Width ≤ 630 ms, Duty Cycle = 10%.

2N3330

CASE 20-03, STYLE 5
TO-72 (TO-206AF)

JFET AMPLIFIER

P-CHANNEL — DEPLETION

Refer to 2N5460 for graphs.

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	20	Vdc
Reverse Gate-Source Voltage	V_{GSR}	20	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.3 1.7	Watts mW/°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 10\ \mu Adc$, $V_{DS} = 0$)	$V_{(BR)GSS}$	20	—	Vdc
Gate Reverse Current ($V_{GS} = 10$ Vdc, $V_{DS} = 0$) ($V_{GS} = 10$ Vdc, $V_{DS} = 0$, $T_A = 150°C$)	I_{GSS}	 — —	 10 10	 nAdc µAdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current(1) ($V_{DS} = -10$ Vdc, $V_{GS} = 0$)	I_{DSS}	2.0	6.0	mAdc
Gate-Source Voltage ($V_{DG} = -15$ Vdc, $I_D = 10\ \mu Adc$)	V_{GS}	—	6.0	Vdc
Drain-Source Resistance ($I_D = 100\ \mu Adc$, $V_{GS} = 0$)	r_{DS}	—	800	Ohms
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance(1) ($V_{DS} = -10$ Vdc, $I_D = 2.0$ mAdc, f = 1.0 kHz) ($V_{DS} = -10$ Vdc, $I_D = 2.0$ mAdc, f = 10 MHz)	$\|y_{fs}\|$	 1500 1350	 3000 —	µmhos
Output Admittance ($V_{DS} = -10$ Vdc, $I_D = 2.0$ mAdc, f = 1.0 kHz)	$\|y_{os}\|$	—	40	µmhos
Reverse Transfer Conductance ($V_{DS} = -10$ Vdc, $I_D = 2.0$ mAdc, f = 1.0 kHz)	$\|y_{rs}\|$	—	0.1	µmhos
Input Conductance ($V_{DS} = -10$ Vdc, $I_D = 2.0$ mAdc, f = 1.0 kHz)	$\|y_{is}\|$	—	0.2	µmhos
Input Capacitance ($V_{DS} = -10$ Vdc, $V_{GS} = 1.0$ Vdc, f = 1.0 MHz)	C_{iss}	—	20	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure ($V_{DS} = -5.0$ Vdc, $I_D = 1.0$ mAdc, $R_G = 1.0$ Megohm, f = 1.0 kHz)	NF	—	3.0	dB

(1) Pulse Test: Pulse Width ≤ 630 ms, Duty Cycle ≤ 10%.

2N3331

CASE 20-03, STYLE 5
TO-72 (TO-206AF)

JFET
LOW-FREQUENCY

P-CHANNEL — DEPLETION

Refer to 2N5460 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	20	Vdc
Drain-Gate Voltage	V_{DG}	20	Vdc
Gate-Source Voltage	V_{GS}	20	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.7	mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 10 μA)	$V_{(BR)GSS}$	20	—	Vdc
Gate Reverse Current (V_{GS} = 10 V, V_{DS} = 0)	I_{GSS}	—	10	nA
Gate Source Cutoff Voltage (V_{DS} = −15 V, I_D = −10 μA)	$V_{GS(off)}$	—	8.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V_{DS} = −10 V, V_{GS} = 0 V)	I_{DSS}*	−5.0	−15.0	mA
Drain-Source Resistance (I_D = −100 μA, V_{GS} = 0)	r_{DS}	—	800	ohms
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = −10 V, I_D = −5.0 mA, f = 1.0 kHz)	$\|y_{fs}\|$*	2000	4000	μmhos
Output Admittance (V_{DS} = −10 V, I_D = −2.0 mA, f = 1.0 kHz)	$\|y_{os}\|$*	—	100	μmhos
Forward Transfer Admittance (V_{DS} = −10 V, I_D = −2.0 mA, f = 10 MHz)	y_{fs}*	1350	—	μmhos
Input Capacitance (V_{DS} = −10 V, V_{GS} = 1.0 V, f = 1.0 MHz)	C_{iss}	—	20	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure (V_{DS} = −5.0 V, I_D = −1.0 mA, R_G = 1.0 MΩ, f = 1.0 kHz)	NF	—	4.0	dB

*Pulse Width ≤ 300 μs, Duty Cycle ≤ 10%.

6

2N3436
2N3437
2N3438

CASE 22-03, STYLE 4
TO-18 (TO-206AA)

JFET
LOW-FREQUENCY

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	50	Vdc
Gate-Source Voltage	V_{GS}	50	Vdc
Gate Current	I_G	10	mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 1.7	mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = 1.0\ \mu A$)		$V_{(BR)GSS}$	50	—	Vdc
Gate Reverse Current ($V_{GS} = -30$ V)		I_{GSS}	—	0.5	nA
Gate Source Cutoff Voltage ($V_{DS} = 20$ V, $I_D = 1.0$ nA)	2N3436 2N3437 2N3438	$V_{GS(off)}$	— — —	10.0 5.0 2.5	Vdc
Gate Source Voltage ($V_{DS} = 20$ V, $I_D = 1.0\ \mu A$)	2N3436 2N3437 2N3438	V_{GS}	— — —	9.8 4.8 2.3	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current ($V_{DS} = 20$ V)	2N3436 2N3437 2N3438	I_{DSS}*	3.0 0.8 0.2	15 4.0 1.0	mA
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance ($V_{DS} = 20$ V, f = 1.0 kHz)	2N3436 2N3437 2N3438	$\|y_{fs}\|$	2500 1500 800	10000 6000 4500	μmhos
Output Admittance ($V_{DS} = 30$ V, f = 1.0 kHz)	2N3436 2N3437 2N3438	$\|y_{os}\|$	— — —	35 20 5	μmhos
Input Capacitance ($V_{DS} = 10$ V) ($V_{DS} = 6.0$ V) ($V_{DS} = 4.0$ V, f = 1.0 MHz)	 2N3436 2N3437 2N3438	C_{iss}	—	18	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure ($V_{DS} = 10$ V, $R_G = 1.0$ mΩ, f = 1.0 kHz)		NF	—	2.0	dB

*Pulse Width ≤ 630 msec, Duty Cycle ≤ 10%.

2N3458
2N3459
2N3460

CASE 22-03, STYLE 4
TO-18 (TO-206AA)

JFET
LOW-FREQUENCY/
LOW NOISE

N-CHANNEL — DEPLETION

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	50	Vdc
Gate-Source Voltage	V_{GS}	50	Vdc
Gate Current	I_G	10	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.7	mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μA)		$V_{(BR)GSS}$	−50	—	Vdc
Gate Reverse Current (V_{GS} = −30 V)		I_{GSS}	—	−.25	nA
Gate Source Cutoff Voltage (V_{DS} = 20, I_D = 1.0 μA)	2N3458 2N3459 2N3460	$V_{GS(off)}$	— — —	−7.8 −3.4 −1.8	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain (V_{DS} = 20 Volts)	2N3458 2N3459 2N3460	I_{DSS}*	3.0 0.8 0.2	15.0 4.0 1.0	mA
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 20 Volts, f = 1.0 kHz)	2N3458 2N3459 2N3460	$\|y_{fs}\|$*	2500 1500 800	10000 6000 4500	μmhos
Output Admittance (V_{DS} = 30 Volts, f = 1.0 kHz)	2N3458 2N3459 2N3460	$\|y_{os}\|$	— — —	35 20 5	μmhos
Input Capacitance (V_{DS} = 10 V)		C_{iss}	—	18	pF
Output Capacitance (V_{DS} = 30 V)		C_{oss}	—	5.0	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DS} = 10 V, f = 20 Hz, R_G = 1.0 MΩ)	2N3458 2N3459 2N3460	NF	— — —	6.0 4.0 4.0	dB

*Pulse Width ≤ 100 msec, Duty Cycle ≤ 10%.

2N3796
2N3797

CASE 22-03, STYLE 2
TO-18 (TO-206AA)

MOSFET
LOW-POWER AUDIO

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage 2N3796 2N3797	V_{DS}	 25 20	Vdc
Gate-Source Voltage	V_{GS}	±10	Vdc
Drain Current	I_D	20	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Junction Temperature Range	T_J	+175	°C
Storage Channel Temperature Range	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain-Source Breakdown Voltage (V_{GS} = −4.0 V, I_D = 5.0 μA) (V_{GS} = −7.0 V, I_D = 5.0 μA)	 2N3796 2N3797	$V_{(BR)DSX}$	 25 20	 30 25	 — —	Vdc
Gate Reverse Current(1) (V_{GS} = −10 V, V_{DS} = 0) (V_{GS} = −10 V, V_{DS} = 0, T_A = 150°C)		I_{GSS}	 — —	 — —	 1.0 200	pAdc
Gate Source Cutoff Voltage (I_D = 0.5 μA, V_{DS} = 10 V) (I_D = 2.0 μA, V_{DS} = 10 V)	 2N3796 2N3797	$V_{GS(off)}$	 — —	 −3.0 −5.0	 −4.0 −7.0	Vdc
Drain-Gate Reverse Current(1) (V_{DG} = 10 V, I_S = 0)		I_{DGO}	—	—	1.0	pAdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current (V_{DS} = 10 V, V_{GS} = 0)	 2N3796 2N3797	I_{DSS}	 0.5 2.0	 1.5 2.9	 3.0 6.0	mAdc
On-State Drain Current (V_{DS} = 10 V, V_{GS} = +3.5 V)	 2N3796 2N3797	$I_{D(on)}$	 7.0 9.0	 8.3 14	 14 18	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = 10 V, V_{GS} = 0, f = 1.0 kHz) (V_{DS} = 10 V, V_{GS} = 0, f = 1.0 MHz)	 2N3796 2N3797 2N3796 2N3797	$\|y_{fs}\|$	 900 1500 900 1500	 1200 2300 — —	 1800 3000 — —	μmhos
Output Admittance (V_{DS} = 10 V, V_{GS} = 0, f = 1.0 kHz)	 2N3796 2N3797	$\|y_{os}\|$	 — —	 12 27	 25 60	μmhos
Input Capacitance (V_{DS} = 10 V, V_{GS} = 0, f = 1.0 MHz)	 2N3796 2N3797	C_{iss}	 — —	 5.0 6.0	 7.0 8.0	pF
Reverse Transfer Capacitance (V_{DS} = 10 V, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	0.5	0.8	pF
FUNCTIONAL CHARACTERISTICS						
Noise Figure (V_{DS} = 10 V, V_{GS} = 0, f = 1.0 kHz, R_S = 3 megohms)		NF	—	3.8	—	dB

(1) This value of current includes both the FET leakage current as well as the leakage current associated with the test socket and fixture when measured under best attainable conditions.

TYPICAL DRAIN CHARACTERISTICS

FIGURE 1 — 2N3796

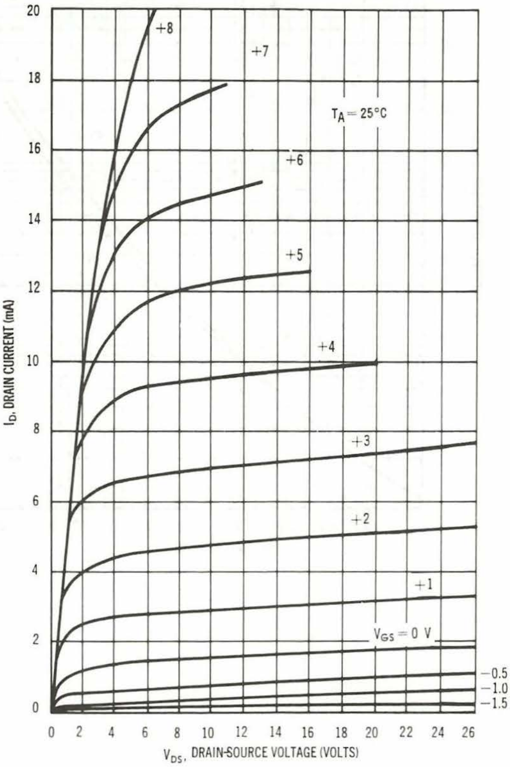
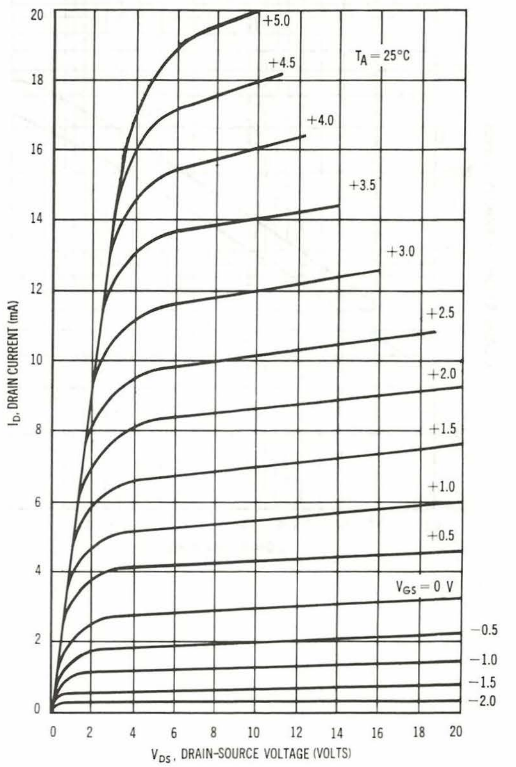


FIGURE 2 — 2N3797



COMMON SOURCE TRANSFER CHARACTERISTICS

FIGURE 3 — 2N3796

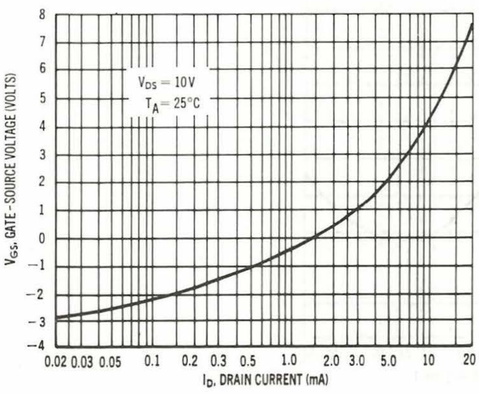
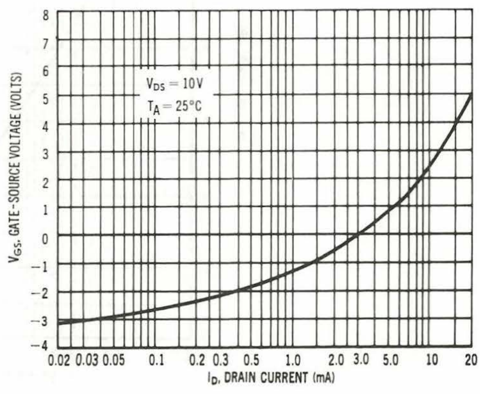


FIGURE 4 — 2N3797



6

FIGURE 5 — FORWARD TRANSFER ADMITTANCE

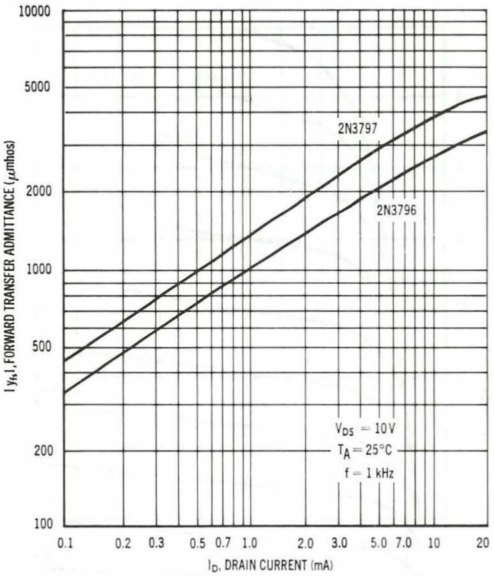
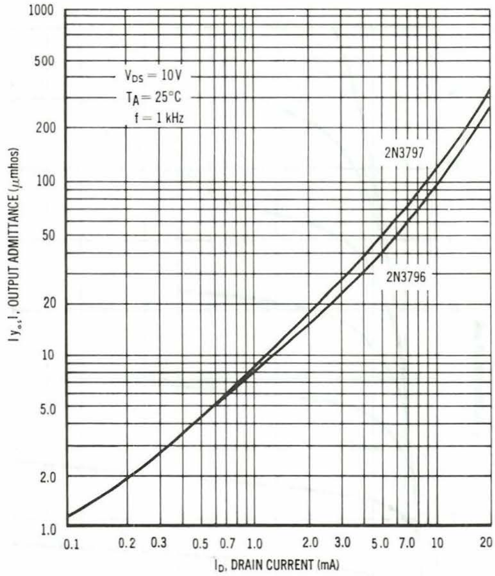
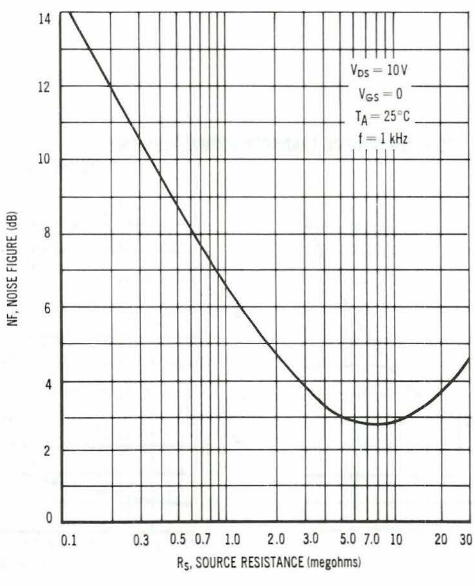


FIGURE 6 — OUTPUT ADMITTANCE



6

FIGURE 7 — NOISE FIGURE



2N3821
2N3822
2N3824

CASE 20-03, STYLE 1
TO-72 (TO-206AF)

JFET
LOW FREQUENCY, LOW NOISE

N-CHANNEL — DEPLETION
JAN 2N3821 AND JAN 2N3822 AVAILABLE

Refer to 2N4220 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	50	Vdc
Drain-Gate Voltage	V_{DG}	50	Vdc
Gate-Source Voltage	V_{GS}	−50	Vdc
Drain Current	I_D	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Junction Temperature Range	T_J	175	°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = −1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	−50	—	Vdc
Gate Reverse Current (V_{GS} = −30 Vdc, V_{DS} = 0) (V_{GS} = −30 Vdc, V_{DS} = 0, T_A = 150°C)		I_{GSS}	 — —	 −0.1 −100	nAdc
Gate Source Cutoff Voltage (I_D = 0.5 nAdc, V_{DS} = 15 Vdc)	 2N3821 2N3822	$V_{GS(off)}$	 — —	 −4.0 −6.0	Vdc
Gate Source Voltage (I_D = 50 μAdc, V_{DS} = 15 Vdc) (I_D = 200 μAdc, V_{DS} = 15 Vdc)	 2N3821 2N3822	V_{GS}	 −0.5 −1.0	 −2.0 −4.0	Vdc
Drain Cutoff Current (V_{DS} = 15 Vdc, V_{GS} = −8.0 Vdc) (V_{DS} = 15 Vdc, V_{GS} = −8.0 Vdc, T_A = 150°C)	 2N3824 2N3824	$I_{D(off)}$	 — —	 0.1 100	nAdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 15 Vdc, V_{GS} = 0)	 2N3821 2N3822	I_{DSS}	 0.5 2.0	 2.5 10	mAdc
Static Drain-Source On Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	 2N3824	$r_{DS(on)}$	—	250	Ohms
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)(1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	 2N3821 2N3822 2N3821 2N3822	$\|y_{fs}\|$	 1500 3000 1500 3000	 4500 6500 — —	μmhos
Output Admittance(1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	 2N3821 2N3822	$\|y_{os}\|$	 — —	 10 20	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	6.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz) (V_{GS} = −8.0 Vdc, V_{DS} = 0, f = 1.0 MHz)	 2N3821 2N3822 2N3824	C_{rss}	 — — —	 3.0 3.0 3.0	pF

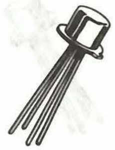
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_S = 1.0 megohm, f = 10 Hz, Noise Bandwidth = 5.0 Hz)	2N3821, 2N3822	NF	—	5.0	dB
Equivalent Input Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, f = 10 Hz, Noise Bandwidth = 5.0 Hz)	2N3821, 2N3822	e_n	—	200	nv/Hz½

(1) Pulse Test: Pulse Width ≤ 100 ms, Duty Cycle ≤ 10%.

2N3823

JAN, JANTX AVAILABLE
CASE 20-03, STYLE 1
TO-72 (TO-206AF)



JFET
VHF AMPLIFIER

N-CHANNEL — DEPLETION

Refer to 2N4416 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	−30	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 2.0	mW mW/°C
Junction Temperature Range	T_J	175	°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = -1.0\ \mu$Adc, $V_{DS} = 0$)	$V_{(BR)GSS}$	−30	—	Vdc
Gate Reverse Current ($V_{GS} = -20$ Vdc, $V_{DS} = 0$) ($V_{GS} = -20$ Vdc, $V_{DS} = 0$, $T_A = 150°C$)	I_{GSS}	 — —	 −0.5 −500	nAdc
Gate Source Cutoff Voltage ($I_D = 0.5$ nAdc, $V_{DS} = 15$ Vdc)	$V_{GS(off)}$	—	−8.0	Vdc
Gate Source Voltage ($I_D = 0.4$ mAdc, $V_{DS} = 15$ Vdc)	V_{GS}	−1.0	−7.5	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current(1) ($V_{DS} = 15$ Vdc, $V_{GS} = 0$)	I_{DSS}	4.0	20	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)(1) ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 200 MHz)	$\lvert y_{fs} \rvert$	 3500 3200	 6500 —	μmhos
Input Admittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 200 MHz)	$Re(y_{is})$	—	800	μmhos
Output Conductance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)(1) ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 200 MHz)	 $\lvert y_{os} \rvert$ $Re(y_{os})$	 — —	 35 200	μmhos
Input Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)	C_{iss}	—	6.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)	C_{rss}	—	2.0	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, $R_S = 1000$ ohms, f = 100 MHz)	NF	—	2.5	dB

(1) Pulse Test: Pulse Width = 100 ms, Duty Cycle ≤ 10%.

6

2N3909,A

CASE 20-03, STYLE 5
TO-72 (TO-206AF)

JFET
AMPLIFIER

P-CHANNEL — DEPLETION

Refer to 2N5460 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	−20	Vdc
Drain-Gate Voltage	V_{DG}	−20	Vdc
Reverse Gate-Source Voltage	V_{GSR}	20	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Forward Gate-Source Voltage	V_{GSF}	20	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.) (1)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	20	—	Vdc
Gate Reverse Current (V_{GS} = 10 Vdc, V_{DS} = 0) (V_{GS} = 10 Vdc, V_{DS} = 0, T_A = 100°C)		I_{GSS}	 — —	 10 1.0	 nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = −10 Vdc, I_D = 10 μAdc)	 2N3909 2N3909A	$V_{GS(off)}$	 — —	 8.0 8.0	Vdc
Gate Source Voltage (V_{DS} = −10 Vdc, I_D = 30 μAdc)		V_{GS}	0.3	7.9	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(2) (V_{DS} = −10 Vdc, V_{GS} = 0)	 2N3909 2N3909A	I_{DSS}	 0.3 1.0	 15 15	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance(2) (V_{DS} = −10 Vdc, V_{GS} = 0, f = 1.0 kHz)	 2N3909 2N3909A	$\|y_{fs}\|$	 1000 2200	 5000 5000	μmhos
(V_{DS} = −10 Vdc, V_{GS} = 0, f = 10 MHz)	2N3909 2N3909A		900 2000	— —	
Output Admittance (V_{DS} = −10 Vdc, V_{GS} = 0, f = 1.0 kHz)		$\|y_{os}\|$	—	100	μmhos
Input Capacitance (V_{DS} = −10 Vdc, V_{GS} = 0, f = 1.0 MHz)	 2N3909 2N3909A	C_{iss}	 — —	 32 9.0	pF
Reverse Transfer Capacitance (V_{DS} = −10 Vdc, V_{GS} = 0, f = 1.0 MHz)	 2N3909 2N3909A	C_{rss}	 — —	 16 3.0	pF

(1) The fourth lead (case) is connected to the source for all measurements.
(2) Pulse Test: Pulse Width ≤ 630 ms, Duty Cycle ≤ 10%.

2N3966

CASE 20-03, STYLE 1
TO-72 (TO-206AF)

JFET
HIGH-FREQUENCY AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Gate Current	I_G	10	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C (Free Air)	P_D	300 1.71	mW mW/°C
Lead Temperature (1/16″ from Case for 10 Seconds)	T_L	300	°C
Storage Temperature Range	T_{stg}	−55 to 200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 1.0 μA, V_{DS} = 0)	$V_{(BR)GSS}$	−30	—	Vdc
Gate Reverse Current (V_{GS} = 20 V, V_{DS} = 0)	I_{GSS}	—	0.1	nA
Drain Cutoff Current (V_{DS} = 10 V, V_{GS} = −7.0 V, T_A = 150°C)	$I_{D(off)}$	—	2.0	μA
Gate Source Cutoff Voltage (I_D = 10 nA, V_{DS} = 10 V)	$V_{GS(off)}$	4.0	6.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V_{DS} = 20 V, V_{GS} = 0)	I_{DSS}	2.0	—	mA
Drain-Source "ON" Voltage (I_D = 1.0 mA, V_{GS} = 0 V)	$V_{DS(on)}$	—	0.25	Vdc
Drain Reverse Current (V_{DG} = 20 V, I_S = 0 A) (25°C) (150°C)	I_{DGO}	— —	0.1 0.2	nA μA
Static Drain-Source On Resistance (V_{GS} = 0 V, I_D = 0, f = 1.0 kHz)	$r_{DS(on)}$	—	220	Ω
SMALL-SIGNAL CHARACTERISTICS				
Input Capacitance (V_{DS} = 20 V, V_{GS} = 0 V, f = 1.0 MHz)	C_{iss}	—	6.0	pF
Reverse Transfer Capacitance (V_{DS} = 0 V, V_{GS} = 7.0 V, f = 1.0 MHz)	C_{rss}	—	1.5	pF
SWITCHING CHARACTERISTICS				
Delay Time (See Figure 1)	t_d	—	0.02	μsec
Rise Time (See Figure 1)	t_r	—	100	nsec
Turn-Off Time (See Figure 1)	t_{off}	—	100	nsec

6

2N3970
2N3971
2N3972

CASE 22-03, STYLE 4
TO-18 (TO-206AA)

JFET
SWITCHING

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Reverse Gate-Source Voltage	V_{GSR}	40	Vdc
Forward Gate Current	I_{GF}	50	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.8 10	Watts mW/°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = 1.0\ \mu Adc$, $V_{GS} = 0$)		$V_{(BR)GSS}$	40	—	Vdc
Gate Reverse Current ($V_{GS} = 20$ Vdc, $V_{DS} = 0$)		I_{GSS}	—	250	pAdc
Drain Reverse Current ($V_{DG} = 20$ Vdc, $I_S = 0$) ($V_{DG} = 20$ Vdc, $I_S = 0$, $T_A = 150°C$)		I_{DGO}	— —	250 500	pAdc nAdc
Drain Cutoff Current ($V_{DS} = 20$ Vdc, $V_{GS} = -12$ Vdc) ($V_{DS} = 20$ Vdc, $V_{GS} = -12$ Vdc, $T_A = 150°C$)		$I_{D(off)}$	— —	250 500	pAdc nAdc
Gate Source Voltage ($V_{DS} = 20$ Vdc, $I_D = 1.0$ nAdc)	2N3970 2N3971 2N3972	V_{GS}	4.0 2.0 0.5	10 5.0 3.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) ($V_{DS} = 20$ Vdc, $V_{GS} = 0$)	2N3970 2N3971 2N3972	I_{DSS}	50 25 5.0	150 75 30	mAdc
Drain-Source On-Voltage ($I_D = 20$ mAdc, $V_{GS} = 0$) ($I_D = 10$ mAdc, $V_{GS} = 0$) ($I_D = 5.0$ mAdc, $V_{GS} = 0$)	2N3970 2N3971 2N3972	$V_{DS(on)}$	— — —	1.0 1.5 2.0	Vdc
Static Drain-Source On Resistance ($I_D = 1.0$ mAdc, $V_{GS} = 0$)	2N3970 2N3971 2N3972	$r_{DS(on)}$	— — —	30 60 100	Ohms
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance ($V_{GS} = 0$, $I_D = 0$, f = 1.0 kHz)	2N3970 2N3971 2N3972	$r_{ds(on)}$	— — —	30 60 100	Ohms
Input Capacitance ($V_{DS} = 20$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)		C_{iss}	—	25	pF
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = -12$ Vdc, f = 1.0 MHz)		C_{rss}	—	6.0	pF

SWITCHING CHARACTERISTICS

Characteristic	Test Condition		Symbol	Min	Max	Unit
Turn-On Delay Time	Test Condition for 2N3970: ($V_{DD} = 10$ Vdc, $V_{GS(on)} = 0$, $I_{D(on)} = 20$ mAdc, $V_{GS(off)} = 10$ Vdc)	2N3970 2N3971 2N3972	$t_{d(on)}$	— — —	10 15 40	ns
Rise Time	Test Condition for 2N3971: ($V_{DD} = 10$ Vdc, $V_{GS(on)} = 0$, $I_{D(on)} = 10$ mAdc, $V_{GS(on)} = 5.0$ Vdc)	2N3970 2N3971 2N3972	t_r	— — —	10 15 40	ns
Turn-Off Time	Test Condition for 2N3972: ($V_{DD} = 10$ Vdc, $V_{GS(on)} = 0$, $I_{D(on)} = 5.0$ mAdc, $V_{GS(off)} = 3.0$ Vdc)	2N3970 2N3971 2N3972	t_{off}	— — —	30 60 100	ns

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 3.0%.

2N3993,A
2N3994,A

CASE 20-03, STYLE 5
TO-72 (TO-206AF)

JFET
SWITCHING

P-CHANNEL — DEPLETION

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	−25	Vdc
Drain-Gate Voltage	V_{DG}	−25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	25	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	25	—	Vdc
Drain Reverse Current (V_{DG} = −15 Vdc, I_S = 0) (V_{DG} = −15 Vdc, I_S = 0, T_A = 150°C)		I_{DGO}	 — —	 1.2 1.2	 nAdc μAdc
Drain Cutoff Current (V_{DS} = −10 Vdc, V_{GS} = 10 Vdc) (V_{DS} = −10 Vdc, V_{GS} = 6.0 Vdc) (V_{DS} = −10 Vdc, V_{GS} = 10 Vdc, T_A = 150°) (V_{DS} = −10 Vdc, V_{GS} = 6.0 Vdc, T_A = 150°)	 2N3993, 2N3993A 2N3994, 2N3994A 2N3993, 2N3993A 2N3994, 2N3994A	$I_{D(off)}$	 — — — —	 1.2 1.2 1.0 1.0	 nAdc μAdc
Gate Source Voltage (V_{DS} = −10 Vdc, I_D = −1.0 μAdc)	 2N3993, 2N3993A 2N3994, 2N3994A	V_{GS}	 4.0 1.0	 9.5 5.5	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) (V_{DS} = −10 Vdc, V_{GS} = 0)	 2N3993, 2N3993A 2N3994, 2N3994A	I_{DSS}	 10 2.0	 — —	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	 2N3993, 2N3993A 2N3994, 2N3994A	$r_{ds(on)}$	 — —	 150 300	Ohms
Forward Transfer Admittance(1) (V_{DS} = −10 Vdc, V_{GS} = 0, f = 1.0 kHz)	 2N3993 2N3993A 2N3994 2N3994A	$\|y_{fs}\|$	 6.0 7.0 4.0 5.0	 12 12 10 10	mmhos
Input Capacitance (V_{DS} = −10 Vdc, V_{GS} = 0, f = 1.0 MHz)	 2N3993, 2N3994 2N3993A, 2N3994A	C_{iss}	 — —	 16 12	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 10 Vdc, f = 1.0 MHz) (V_{DS} = 0, V_{GS} = 6.0 Vdc, f = 1.0 MHz)	 2N3993 2N3993A 2N3994 2N3994A	C_{rss}	 — — — —	 4.5 3.0 5.0 3.5	pF

(1) Pulse Test: Pulse Width = 100 ms, Duty Cycle ≤ 10%.

2N4091
2N4092
2N4093

JAN, JTX AVAILABLE
CASE 22-03, STYLE 3
TO-18 (TO-206AA)

JFET
SWITCHING

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Gate-Source Voltage	V_{GS}	40	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.8 10	Watts mW/°C
Junction Temperature Range	T_J	−65 to +175	°C
Storage Temperature Range	T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = 1.0\ \mu Adc$, $V_{DS} = 0$)		$V_{(BR)GSS}$	40	—	Vdc
Drain-Gate Breakdown Voltage ($I_D = 1.0\ \mu Adc$, $I_S = 0$)		$V_{(BR)DGO}$	40	—	Vdc
Gate Source Cutoff Voltage ($V_{DS} = 20$ Vdc, $I_D = 1.0$ nAdc)	2N4091 2N4092 2N4093	$V_{GS(off)}$	5.0 2.0 1.0	10 7.0 5.0	Vdc
Source Reverse Current ($V_{SG} = 20$ Vdc, $I_D = 0$)		I_{SGO}	—	0.2	nAdc
Drain Reverse Current ($V_{DG} = 20$ Vdc, $I_S = 0$) ($V_{DG} = 20$ Vdc, $I_D = 0$, $T_A = 150°C$)		I_{DGO}	— —	0.2 0.4	nAdc μAdc
Drain-Cutoff Current ($V_{DS} = 20$ Vdc, $V_{GS} = 12$ Vdc) ($V_{DS} = 20$ Vdc, $V_{GS} = 8.0$ Vdc) ($V_{DS} = 20$ Vdc, $V_{GS} = 6.0$ Vdc) ($V_{DS} = 20$ Vdc, $V_{GS} = 12$ Vdc, $T_A = 150°C$) ($V_{DS} = 20$ Vdc, $V_{GS} = 8.0$ Vdc, $T_A = 150°C$) ($V_{DS} = 20$ Vdc, $V_{GS} = 6.0$ Vdc, $T_A = 150°C$)	2N4091 2N4092 2N4093 2N4091 2N4092 2N4093	$I_{D(off)}$	— — — — — —	0.2 0.2 0.2 0.4 0.4 0.4	nAdc μAdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current* ($V_{DS} = 20$ Vdc, $V_{GS} = 0$)	2N4091 2N4092 2N4093	I_{DSS}*	30 15 8.0	— — —	mAdc
Drain-Source On-Voltage ($I_D = 6.6$ mAdc, $V_{GS} = 0$) ($I_D = 4.0$ mAdc, $V_{GS} = 0$) ($I_D = 2.5$ mAdc, $V_{GS} = 0$)	2N4091 2N4092 2N4093	$V_{DS(on)}$	— — —	0.2 0.2 0.2	Vdc
Static Drain-Source On Resistance ($I_D = 1.0$ mAdc, $V_{GS} = 0$)	2N4091 2N4092 2N4093	$r_{DS(on)}$	— — —	30 50 80	Ohms

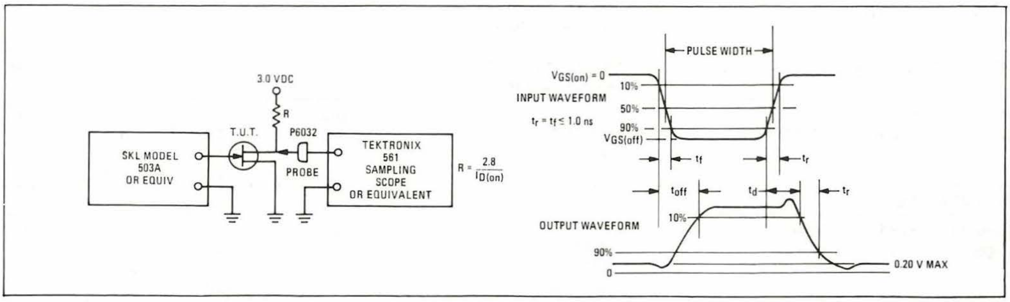
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	2N4091	$r_{ds(on)}$	—	30	Ohms
	2N4092		—	50	
	2N4093		—	80	
Input Capacitance (V_{DS} = 20 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	16	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 20 Vdc, f = 1.0 MHz)		C_{rss}	—	5.0	pF
SWITCHING CHARACTERISTICS					
Delay Time (See Figure 1)		t_d			ns
($I_{D(on)}$ = 6.6 mAdc)	2N4091		—	15	
($I_{D(on)}$ = 4.0 mAdc)	2N4092		—	15	
($I_{D(on)}$ = 2.5 mAdc)	2N4093		—	20	
Rise Time (See Figure 1)		t_r			ns
($I_{D(on)}$ = 6.6 mAdc)	2N4091		—	10	
($I_{D(on)}$ = 4.0 mAdc)	2N4092		—	20	
($I_{D(on)}$ = 2.5 mAdc)	2N4093		—	40	
Turn-Off Time (See Figure 1)		t_{off}			ns
($V_{GS(off)}$ = 12 Vdc)	2N4091		—	40	
($V_{GS(off)}$ = 8.0 Vdc)	2N4092		—	60	
($V_{GS(off)}$ = 6.0 Vdc)	2N4093		—	80	

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 3.0%.

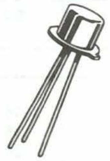
6

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT



2N4117,A
2N4118,A
2N4119,A

CASE 20-03, STYLE 1
TO-72 (TO-206AF)



JFET
AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	−40	Vdc
Drain-Gate Voltage	V_{DG}	−40	Vdc
Gate Current	I_G	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Lead Temperature (1/16″ from case for 10 s)	T_L	255	°C
Storage Temperature Range	T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = −1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	−40	—	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0)	 2N4117,4118,4119 2N4117A,4118A,4119A	I_{GSS}	 — —	 −10 −1.0	 pAdc
(V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 150°C)	2N4117,4118,4119 2N4117A,4118A,4119A		— —	−25 −2.5	nAdc
Gate Source Cutoff Voltage (I_D = 1.0 nAdc, V_{DS} = 10 Vdc)	 2N4117,A 2N4118,A 2N4119,A	$V_{GS(off)}$	 −0.6 −1.0 −2.0	 −1.8 −3.0 −6.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 10 Vdc, V_{GS} = 0)	 2N4117,A 2N4118,A 2N4119,A	I_{DSS}	 0.03 0.08 0.20	 0.09 0.24 0.60	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Input Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	3.0	pF
Reverse Transfer Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	1.5	pF
Forward Transconductance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 kHz)	 2N4117,A 2N4118,A 2N4119,A	g_{fs}	 70 80 100	 210 250 330	μmhos
Output Conductance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 kHz)	 2N4117,A 2N4118,A 2N4119,A	g_{os}	 — — —	 3.0 5.0 10	μmhos

(1) I_{DSS} is measured during a 2.0-ms interval 100 ms after power is applied. (NOT a JEDEC condition.)

FIGURE 1 – TRANSFER CHARACTERISTICS

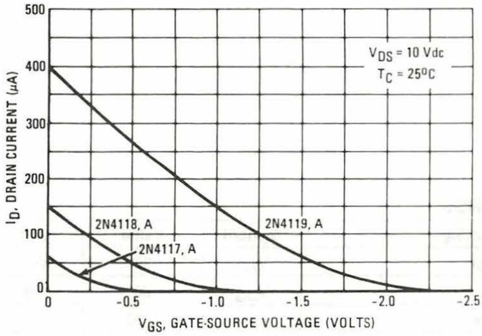
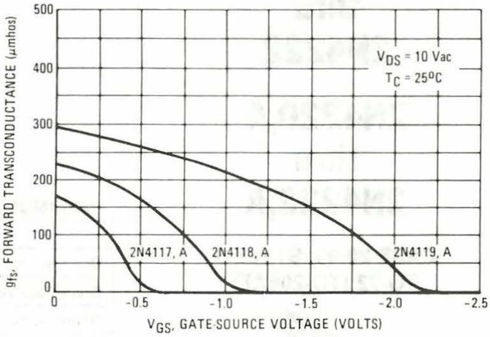


FIGURE 2 – TRANSCONDUCTANCE CHARACTERISTICS



6

2N4220 thru 2N4222

2N4220,A thru 2N4222,A

CASE 20-03, STYLE 3
TO-72 (TO-206AF)

JFET
LOW-FREQUENCY, LOW NOISE

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	−30	Vdc
Drain Current	I_D	15	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2	mW mW/°C
Junction Temperature Range	T_J	175	°C
Storage Channel Temperature Range	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = −10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	−30	—	—	Vdc
Gate Reverse Current (V_{GS} = −15 Vdc, V_{DS} = 0) (V_{GS} = −15 Vdc, V_{DS} = 0, T_A = 150°C)		I_{GSS}	 — —	 — —	 −0.1 −100	nAdc
Gate Source Cutoff Voltage (I_D = 0.1 nAdc, V_{DS} = 15 Vdc)	2N4220,A 2N4221,A 2N4222,A	$V_{GS(off)}$	— — —	— — —	−4 −6 −8	Vdc
Gate Source Voltage (I_D = 50 μAdc, V_{DS} = 15 Vdc) (I_D = 200 μAdc, V_{DS} = 15 Vdc) (I_D = 500 μAdc, V_{DS} = 15 Vdc)	 2N4220,A 2N4221,A 2N4222,A	V_{GS}	 −0.5 −1.0 −2.0	 — — —	 −2.5 −5.0 −6.0	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0)	2N4220,A 2N4221,A 2N4222,A	I_{DSS}	0.5 2.0 5.0	— — —	3.0 6.0 15	mAdc
Static Drain-Source On Resistance (V_{DS} = 0, V_{GS} = 0)	2N4220,A 2N4221,A 2N4222,A	$r_{DS(on)}$	— — —	500 400 300	— — —	Ohms
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance Common Source* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N4220,A 2N4221,A 2N4222,A	$\|y_{fs}\|$	1000 2000 2500	— — —	4000 5000 6000	μmhos
Output Admittance Common Source (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N4220,A 2N4221,A 2N4222,A	$\|y_{os}\|$	— — —	— — —	10 20 40	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	4.5	6.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	1.2	2.0	pF
Common-Source Output Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 30 MHz)		C_{osp}	—	1.5	—	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
FUNCTIONAL CHARACTERISTICS						
Noise Figure		NF				dB
(V_{DS} = 15 Vdc, V_{GS} = 0, R_S = 1.0 megohm, f = 100 Hz)	2N4220A		—	—	2.5	
	2N4221A		—	—	2.5	
	2N4222A		—	—	2.5	

*Pulse Test: Pulse Width = 630 ms, Duty Cycle = 10%.

FIGURE 1 — NOISE FIGURE versus FREQUENCY

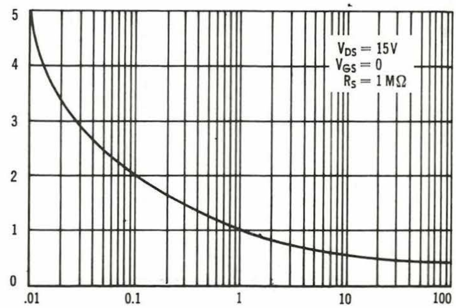


FIGURE 2 — NOISE FIGURE versus SOURCE RESISTANCE

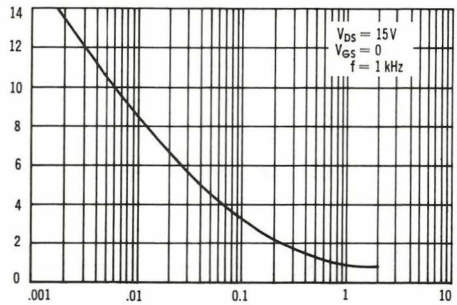


FIGURE 3 — TYPICAL DRAIN CHARACTERISTICS
$V_{GS(off)} \cong -1.2$ VOLTS

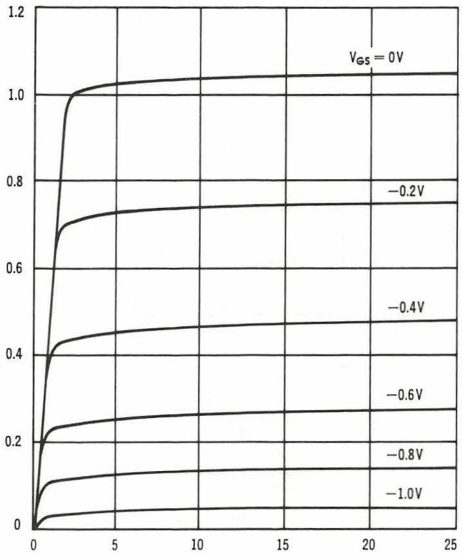


FIGURE 4 — COMMON SOURCE TRANSFER CHARACTERISTICS
$V_{GS(off)} \cong -1.2$ VOLTS

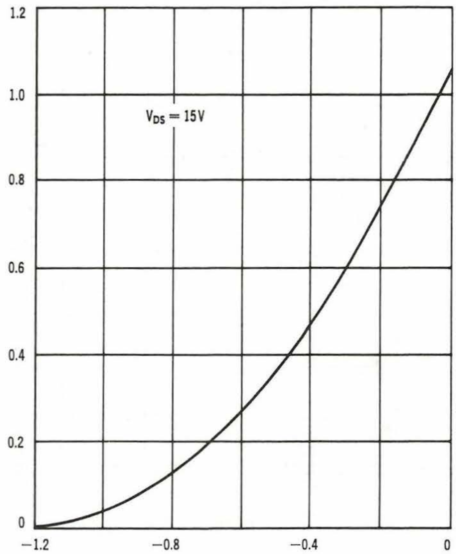


FIGURE 5 — TYPICAL DRAIN CHARACTERISTICS
$V_{GS(off)} \cong -3.5$ VOLTS

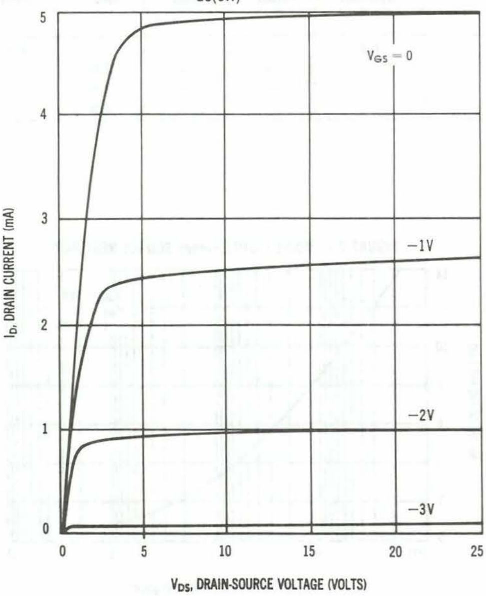


FIGURE 6 — COMMON SOURCE TRANSFER CHARACTERISTICS
$V_{GS(off)} \cong -3.5$ VOLTS

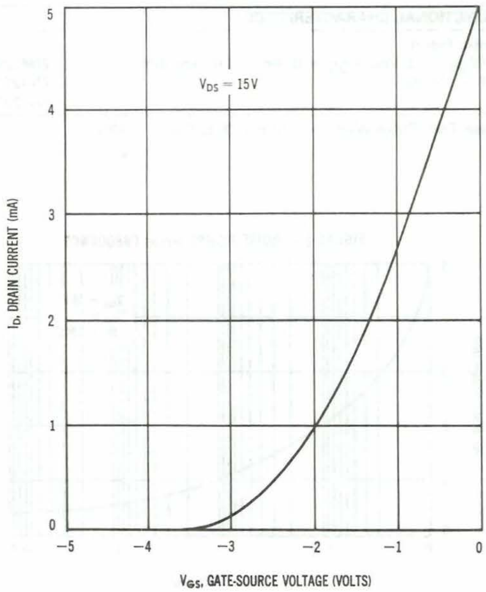


FIGURE 7 — TYPICAL DRAIN CHARACTERISTICS
$V_{GS(off)} \cong -5.8$ VOLTS

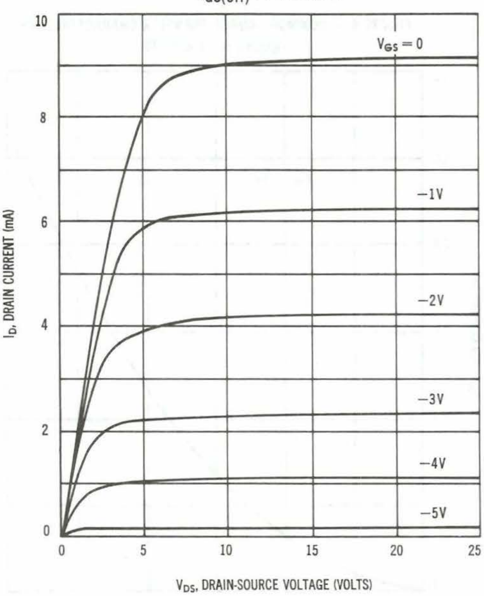
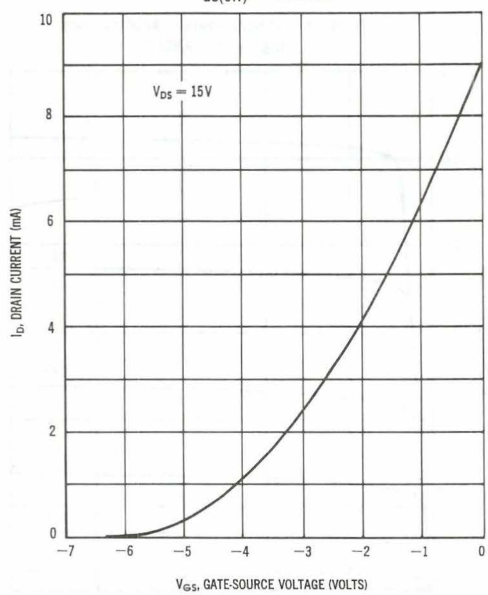


FIGURE 8 — COMMON SOURCE TRANSFER CHARACTERISTICS
$V_{GS(off)} \cong -5.8$ VOLTS



NOTES:
1. Graphical data is presented for dc conditions. Tabular data is given for pulsed conditions (Pulse Width = 630 ms, Duty Cycle = 10%). Under dc conditions, self heating in higher I_{DSS} units reduces I_{DSS} (See Figure 10).
2. Figures 8, 9, 10: Data taken in a standard printed circuit with a TO-18 type socket mounting and 1/4" lead length.

2N4223
2N4224

CASE 20-03, STYLE 3
TO-72 (TO-206AF)

JFET
VHF AMPLIFIER

N-CHANNEL — DEPLETION

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	−30	Vdc
Drain Current	I_D	20	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Operating and Junction Temperature Range	T_J	−65 to +175	°C
Storage Temperature Range	T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = −10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	−30	—	Vdc
Gate Reverse Current (V_{GS} = −20 Vdc, V_{DS} = 0)	2N4223 2N4224	I_{GSS}	— —	−0.25 −0.50	nAdc
(V_{GS} = −20 Vdc, V_{DS} = 0, T_A = 100°C)	2N4223 2N4224		— —	−250 −500	
Gate Source Cutoff Voltage (I_D = 0.25 nAdc, V_{DS} = 15 Vdc) (I_D = 0.50 nAdc, V_{DS} = 15 Vdc)	2N4223 2N4224	$V_{GS(off)}$	−1.2 —	−8.0 −8.0	Vdc
Gate Source Voltage (I_D = 0.3 mAdc, V_{DS} = 15 Vdc) (I_D = 0.2 mAdc, V_{DS} = 15 Vdc)	2N4223 2N4224	V_{GS}	−1.0 −1.0	−7.0 −7.5	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0)	2N4223 2N4224	I_{DSS}	3.0 2.0	18 20	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)*	2N4223 2N4224	$\lvert y_{fs} \rvert$	3000 2000	7000 7500	μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)	2N4223 2N4224		2700 1700	— —	
Input Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)		$Re(y_{is})$	—	800	μmhos
Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)		$Re(y_{os})$	—	200	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	6.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	2.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_S = 1.0 k ohm, f = 200 MHz)	2N4223	NF	—	5.0	dB
Small-Signal Power Gain Common Source (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)	2N4223	G_{ps}	10	—	dB

*Pulse Test: Pulse Width ≤ 630 ms, Duty Cycle ≤ 10%.

6

FIGURE 1—NOISE FIGURE AND POWER GAIN TEST CIRCUIT

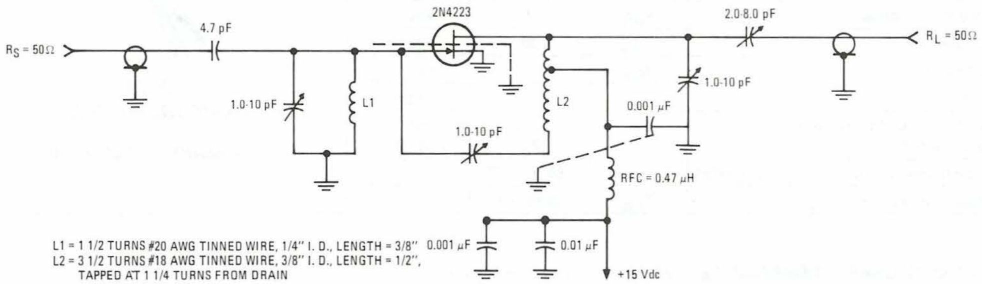


FIGURE 2 — DRAIN CURRENT versus GATE-SOURCE VOLTAGE

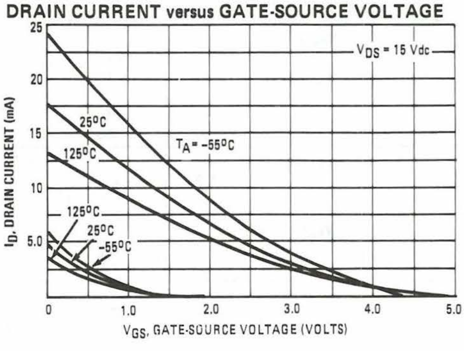


FIGURE 3 — TEMPERATURE COEFFICIENT FOR DRAIN CURRENT

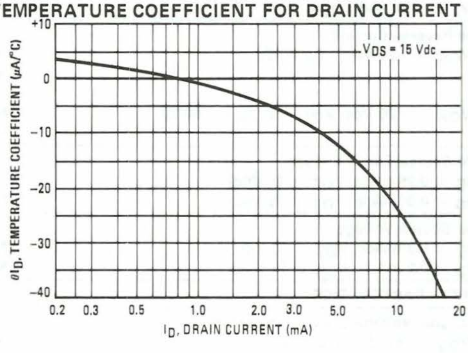


FIGURE 4 — FORWARD TRANSFER ADMITTANCE versus GATE-SOURCE VOLTAGE

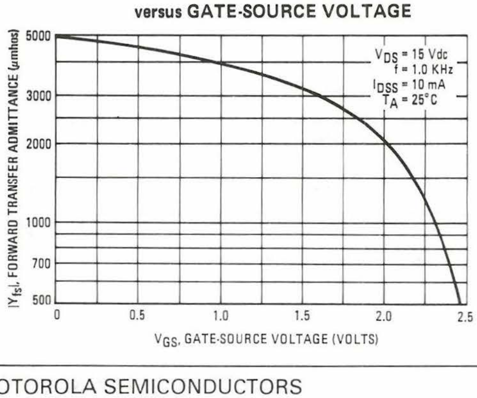


FIGURE 5 — TEMPERATURE COEFFICIENT FOR Y_{fs} versus DRAIN CURRENT

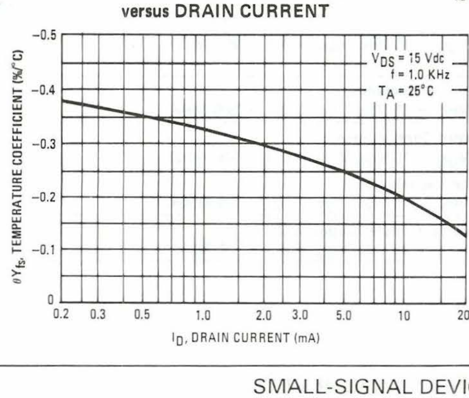


FIGURE 6 — CAPACITANCES

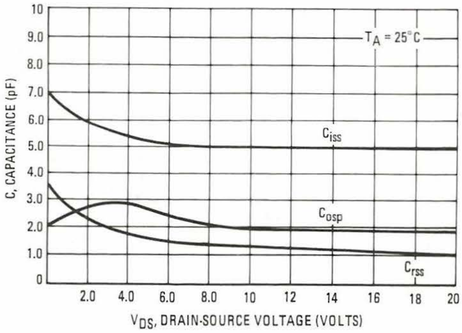


FIGURE 7 — COMMON SOURCE NOISE FIGURE versus SOURCE RESISTANCE

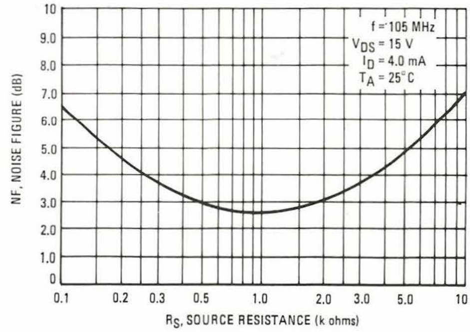


FIGURE 8 — INPUT ADMITTANCE versus FREQUENCY

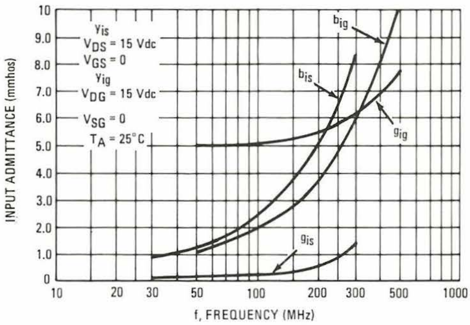


FIGURE 9 — FORWARD TRANSFER ADMITTANCE versus FREQUENCY

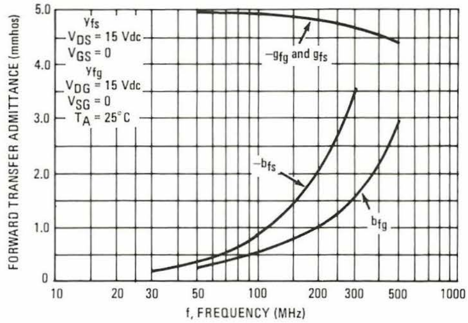


FIGURE 10 — OUTPUT ADMITTANCE versus FREQUENCY

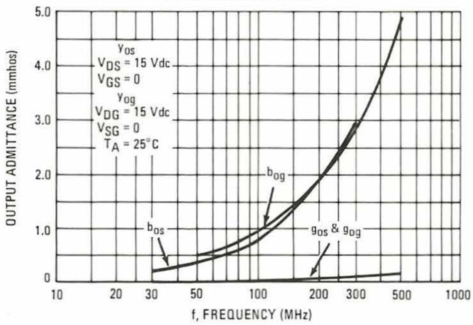
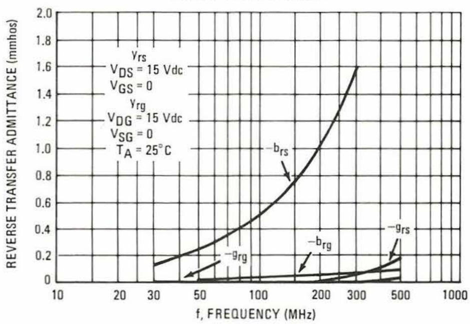


FIGURE 11 — REVERSE TRANSFER ADMITTANCE versus FREQUENCY



6

FIGURE 12 – POWER GAIN versus FREQUENCY

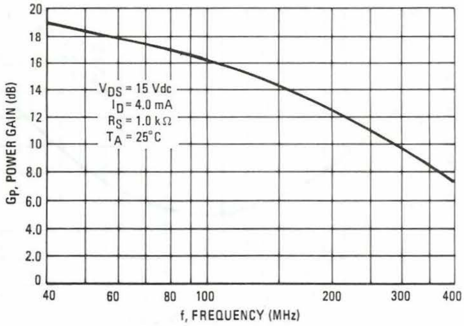
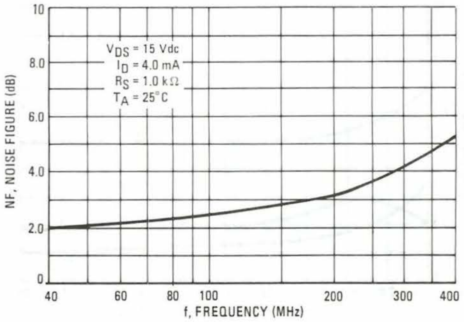


FIGURE 13 – COMMON SOURCE NOISE FIGURE versus FREQUENCY



6

2N4338
2N4339
2N4340
2N4341

CASE 22-03, STYLE 3
TO-18 (TO-206AA)

JFET
LOW-FREQUENCY, LOW NOISE

N-CHANNEL — DEPLETION

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	50	Vdc
Drain-Gate Voltage	V_{DG}	50	Vdc
Gate-Source Voltage	V_{GS}	50	Vdc
Reverse Gate-Source Voltage	V_{GSR}	50	Vdc
Gate Current	I_G	50	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = −1.0 μA)		$V_{(BR)GSS}$	50	—	Vdc
Gate Reverse Current (V_{GS} = −30 V)		I_{GSS}	—	0.1	nA
Gate Source Cutoff Voltage (V_{DS} = 15 V, I_D = 0.1 μA)	2N4338 2N4339 2N4340 2N4341	$V_{GS(off)}$	−0.3 −0.6 −1.0 −2.0	−1.0 −1.8 −3.0 −6.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = 15 V)	2N4338 2N4339 2N4340 2N4341	I_{DSS}*	0.2 0.5 1.2 3.0	0.6 1.5 3.6 9.0	mA
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 15 V, f = 1.0 kHz)	2N4338 2N4339 2N4340 2N4341	$\|y_{fs}\|$*	600 800 1300 2000	1800 2400 3000 4000	μmhos
Output Admittance (V_{DS} = 15 V, f = 1.0 kHz)	2N4338 2N4339 2N4340 2N4341	$\|y_{os}\|$	— — — —	5.0 15 30 60	μmhos
Input Capacitance (V_{DS} = 15 V, f = 1.0 MHz)		C_{iss}	—	6.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 V, f = 1.0 MHz)		C_{rss}	—	2.0	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DS} = 15 Volts, f = 1.0 kHz, R_G = 1.0 MΩ)		NF	—	1.0	dB

*Pulse Test: Pulse Width ≤ 630 msec, Duty Cycle ≤ 10%.

2N4342

CASE 29-02, STYLE 7
TO-92 (TO-226AA)

JFET
HIGH FREQUENCY, LOW NOISE

P-CHANNEL — DEPLETION

Refer to 2N5460 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	−25	Vdc
Drain-Gate Voltage	V_{DG}	−25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	25	Vdc
Forward Gate Current	I_{GF}	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +125	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	25	—	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0) (V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 65°C)	I_{GSS}	 — —	 10 0.5	 nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = −10 Vdc, I_D = 1.0 μAdc)	$V_{GS(off)}$	1.0	5.5	Vdc
Gate Source Voltage (V_{DS} = −10 Vdc, I_D = 0.4 mAdc) (V_{DS} = −10 Vdc, I_D = 1.0 mAdc)	V_{GS}	0.7	5.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V_{DS} = −10 Vdc, V_{GS} = 0)	I_{DSS}	4.0	12	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	$r_{ds(on)}$	—	700	Ohms
Forward Transfer Admittance (V_{DS} = −10 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{fs}\|$	2000	6000	μmhos
Output Admittance (V_{DS} = −10 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{os}\|$	—	75	μmhos
Common Source Forward Transconductance (V_{DS} = −10 Vdc, V_{GS} = 0, f = 1.0 MHz)	$Re(y_{fs})$	1500	—	μmhos
Input Capacitance (V_{DS} = −10 Vdc, V_{CS} = 0, f = 1.0 MHz)	C_{iss}	—	20	pF
Reverse Transfer Capacitance (V_{DS} = −10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	5.0	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure (V_{DS} = −10 Vdc, V_{GS} = 0, R_G = 1.0 Megohm, f = 100 Hz, BW = 15 Hz)	NF	—	1.5	dB
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = −10 Vdc, V_{GS} = 0, f = 100 Hz, BW = 15 Hz)	E_n	—	0.08	$\mu V/\sqrt{Hz}$

2N4351

CASE 20-03, STYLE 2
TO-72 (TO-206AF)

MOS FET SWITCHING

N-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage*	V_{GS}	30	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 1.7	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	800 4.56	mW mW/°C
Junction Temperature Range	T_J	175	°C
Storage Temperature Range	T_{stg}	−65 to +175	°C

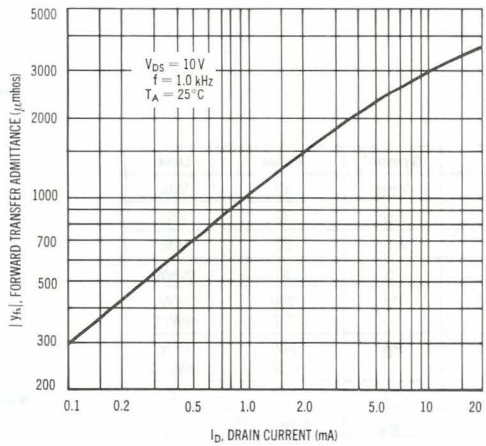
*Transient potentials of ±75 Volt will not cause gate-oxide failure.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage ($I_D = 10\ \mu A$, $V_{GS} = 0$)	$V_{(BR)DSX}$	25	—	Vdc
Zero-Gate-Voltage Drain Current ($V_{DS} = 10$ V, $V_{GS} = 0$) $T_A = 25°C$ $T_A = 150°C$	I_{DSS}	— —	10 10	nAdc μAdc
Gate Reverse Current ($V_{GS} = \pm 15$ Vdc, $V_{DS} = 0$)	I_{GSS}	—	±10	pAdc
ON CHARACTERISTICS				
Gate Threshold Voltage ($V_{DS} = 10$ V, $I_D = 10\ \mu A$)	$V_{GS(Th)}$	1.0	5	Vdc
Drain-Source On-Voltage ($I_D = 2.0$ mA, $V_{GS} = 10$ V)	$V_{DS(on)}$	—	1.0	V
On-State Drain Current ($V_{GS} = 10$ V, $V_{DS} = 10$ V)	$I_{D(on)}$	3.0	—	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance ($V_{DS} = 10$ V, $I_D = 2.0$ mA, f = 1.0 kHz)	$\|y_{fs}\|$	1000	—	μmho
Input Capacitance ($V_{DS} = 10$ V, $V_{GS} = 0$, f = 140 kHz)	C_{iss}	—	5.0	pF
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = 0$, f = 140 kHz)	C_{rss}	—	1.3	pF
Drain-Substrate Capacitance ($V_{D(SUB)} = 10$ V, f = 140 kHz)	$C_{d(sub)}$	—	5.0	pF
Drain-Source Resistance ($V_{GS} = 10$ V, $I_D = 0$, f = 1.0 kHz)	$r_{ds(on}$	—	300	ohms
SWITCHING CHARACTERISTICS				
Turn-On Delay (Fig. 5) — $I_D = 2.0$ mAdc, $V_{DS} = 10$ Vdc, $V_{GS} = 10$ Vdc) (See Figure 9; Times Circuit Determined)	t_{d1}	—	45	ns
Rise Time (Fig. 6)	t_r	—	65	ns
Turn-Off Delay (Fig. 7)	t_{d2}	—	60	ns
Fall Time (Fig. 8)	t_f	—	100	ns

6

FIGURE 1 — FORWARD TRANSFER ADMITTANCE



6

FIGURE 2 — TRANSFER CHARACTERISTICS

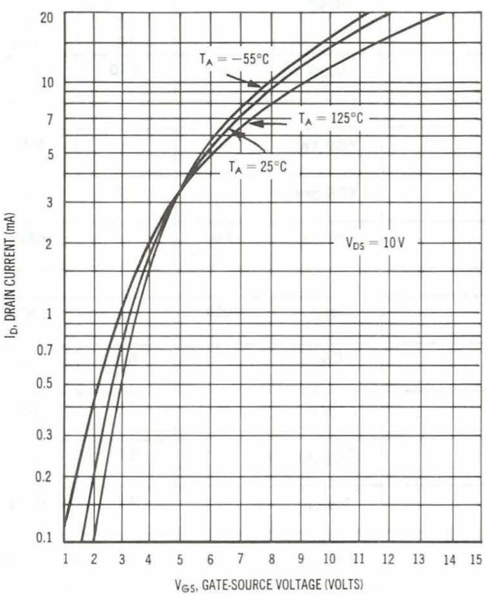


FIGURE 3 — DRAIN-SOURCE "ON" RESISTANCE

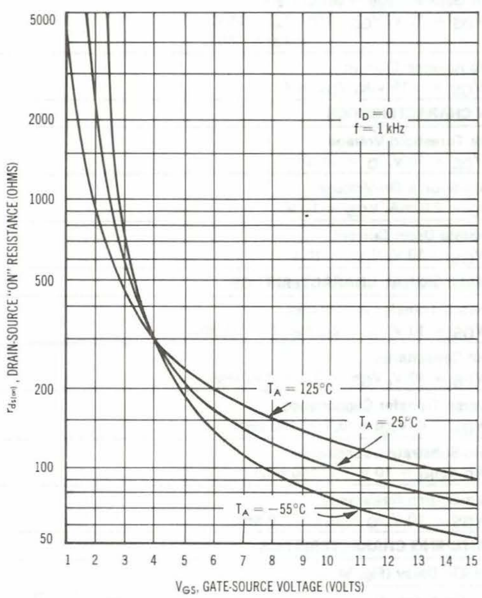
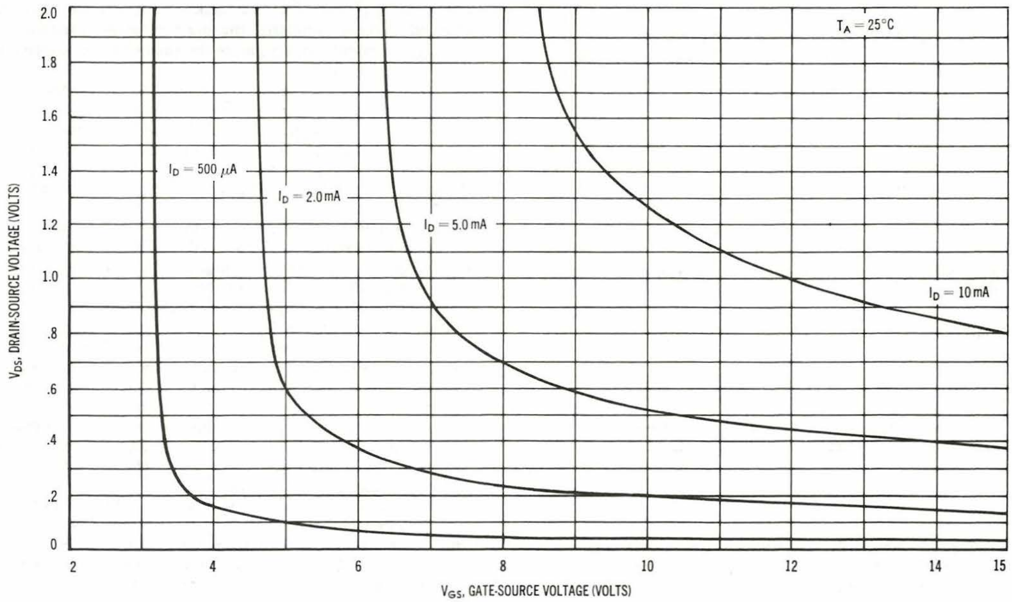


FIGURE 4 — "ON" DRAIN-SOURCE VOLTAGE



SWITCHING CHARACTERISTICS
($T_A = 25°C$)

FIGURE 5 — TURN-ON DELAY TIME

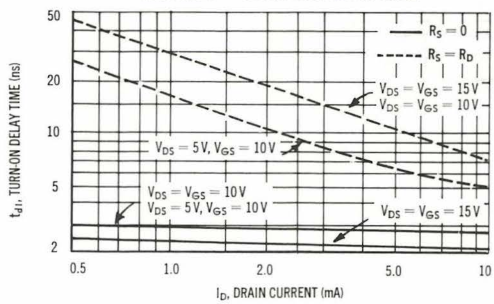


FIGURE 6 — RISE TIME

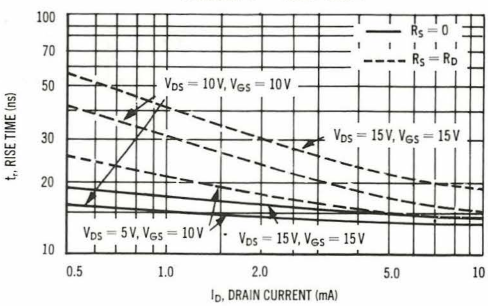


FIGURE 7 — TURN-OFF DELAY TIME

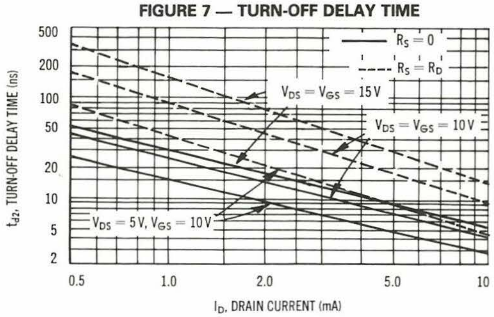


FIGURE 8 — FALL TIME

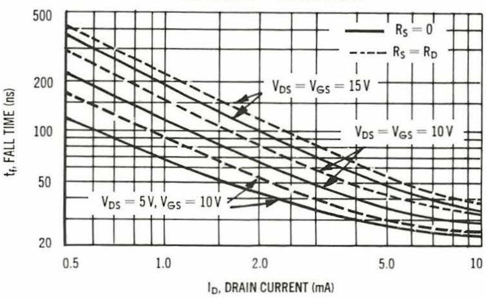
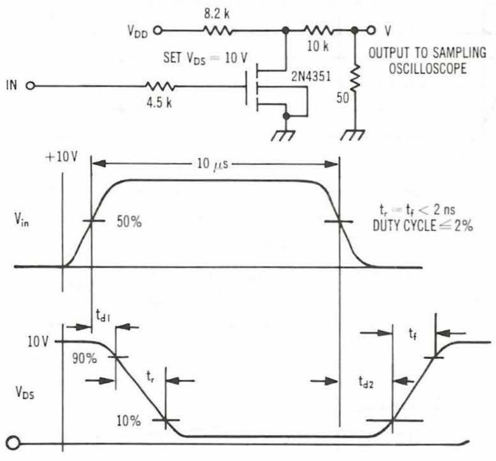


FIGURE 9 — SWITCHING CIRCUIT and WAVEFORMS



The switching characteristics shown above were measured in a test circuit similar to Figure 10. At the beginning of the switching interval, the gate voltage is at ground and the gate-source capacitance ($C_{gs} = C_{iss} - C_{rss}$) has no charge. The drain voltage is at V_{DD}, and thus the feedback capacitance (C_{rss}) is charged to V_{DD}. Similarly, the drain-substrate capacitance ($C_{d(sub)}$) is charged to V_{DD} since the substrate and source are connected to ground.

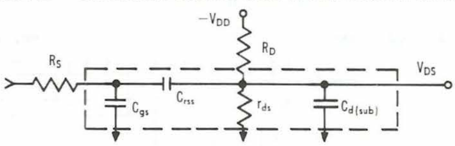
During the turn-on interval, C_{gs} is charged to V_{GS} (the input voltage) through R_S (generator impedance). C_{rss} must be discharged to $V_{GS} - V_{D(on)}$ through R_S and the parallel combination of the load resistor (R_D) and the channel resistance (r_{ds}). In addition, $C_{d(sub)}$ is discharged to a low value ($V_{D(on)}$) through R_D in parallel with r_{ds}. During turn-off this charge flow is reversed.

Predicting turn-on time proves to be somewhat difficult since the channel resistance (r_{ds}) is a function of the gate-source voltage (V_{GS}). As C_{gs} becomes charged, V_{GS} is approaching V_{in} and r_{ds} decreases (see Figure 4) and since C_{rss} and $C_{d(sub)}$ are charged through r_{ds}, turn-on time is quite non-linear.

If the charging time of C_{gs} is short compared to that of C_{rss} and $C_{d(sub)}$, then r_{ds} (which is in parallel with R_D) will be low compared to R_D during the switching interval and will largely determine the turn-on time. On the other hand, during turn-off r_{ds} will be almost an open circuit requiring C_{rss} and $C_{d(sub)}$ to be charged through R_D and resulting in a turn-off time that is long compared to the turn-on time. This is especially noticeable for the curves where $R_S = 0$ and C_{gs} is charged through the pulse generator impedance only.

The switching curves shown with $R_S = R_D$ simulate the switching behavior of cascaded stages where the driving source impedance is normally the same as the load impedance. The set of curves with $R_S = 0$ simulates a low source impedance drive such as might occur in complementary logic circuits.

FIGURE 10 — SWITCHING CIRCUIT MOSFET EQUIVALENT MODEL



2N4352

CASE 20-03, STYLE 2
TO-72 (TO-206AF)

MOS FET
SWITCHING

P-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

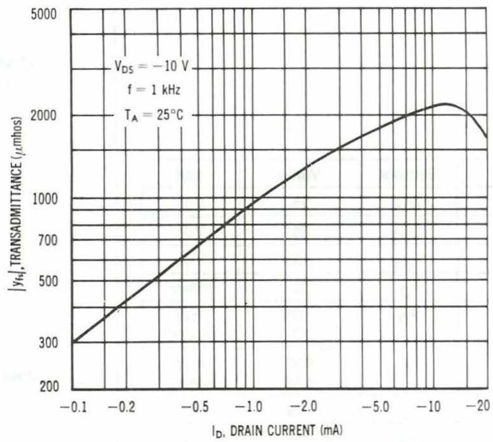
Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	±30	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.7	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	800 4.56	mW mW/°C
Junction Temperature Range	T_J	175	°C
Storage Temperature Range	T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage (I_D = −10 μA, V_{GS} = 0)	$V_{(BR)DSX}$	−25	—	Vdc
Zero-Gate-Voltage Drain Current (V_{DS} = −10 V, V_{GS} = 0) T_A = 25°C T_A = 150°C	I_{DSS}	— —	−10 −10	nAdc μAdc
Gate Reverse Current (V_{GS} = ±30 V, V_{DS} = 0)	I_{GSS}	—	±10	pAdc
ON CHARACTERISTICS				
Gate Threshold Voltage (V_{DS} = −10 V, I_D = −10 μA)	$V_{GS(Th)}$	−1.0	−5.0	Vdc
Drain-Source On-Voltage (I_D = −2.0 mA, V_{GS} = −10 V)	$V_{DS(on)}$	—	−1.0	V
On-State Drain Current (V_{GS} = −10 V_{DS} = −10 V)	$I_{D(on)}$	−3.0	—	mA
SMALL-SIGNAL CHARACTERISTICS				
Drain-Source Resistance (V_{GS} = −10 V, I_D = 0, f = 1.0 kHz)	$r_{ds(on)}$	—	600	ohms
Forward Transfer Admittance (V_{DS} = −10 V, I_D = 2.0 mA, f = 1.0 kHz)	$\|y_{fs}\|$	1000	—	μmho
Input Capacitance (V_{DS} = −10 V, V_{GS} = 0, f = 140 kHz)	C_{iss}	—	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 0, f = 140 kHz)	C_{rss}	—	1.3	pF
Drain-Substrate Capacitance ($V_{D(SUB)}$ = −10 V, f = 140 kHz)	$C_{d(sub)}$	—	4.0	pF
SWITCHING CHARACTERISTICS				
Turn-On Delay (Figures 5) — I_D = −2.0 mAdc, V_{DS} = −10 Vdc, V_{GS} = −10 V) (See Figure 9, Times Circuit Determined)	t_{d1}	—	45	ns
Rise Time (Figures 6)	t_r	—	65	ns
Turn-Off Delay (Figures 7)	t_{d2}	—	60	ns
Fall Time (Figures 8)	t_f	—	100	ns

6

FIGURE 1 — FOWARD TRANSFER ADMITTANCE



6

FIGURE 2 — TRANSFER CHARACTERISTICS

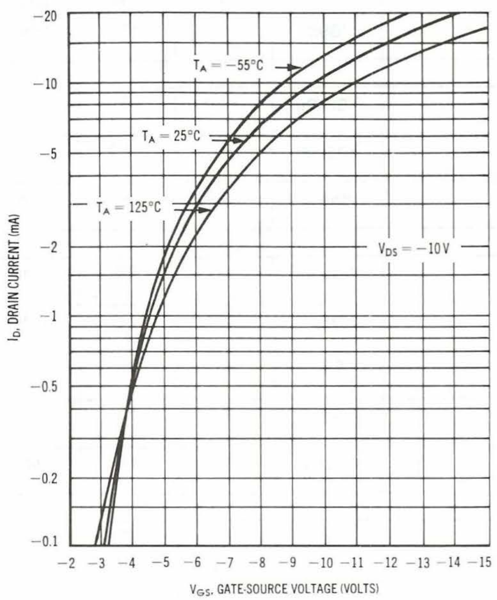


FIGURE 3 — DRAIN-SOURCE "ON" RESISTANCE

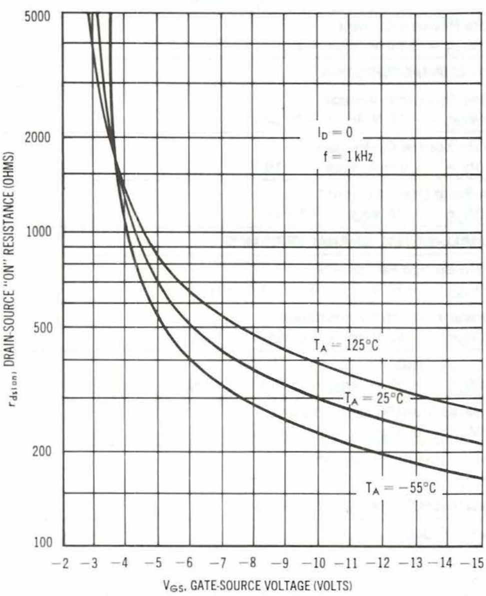
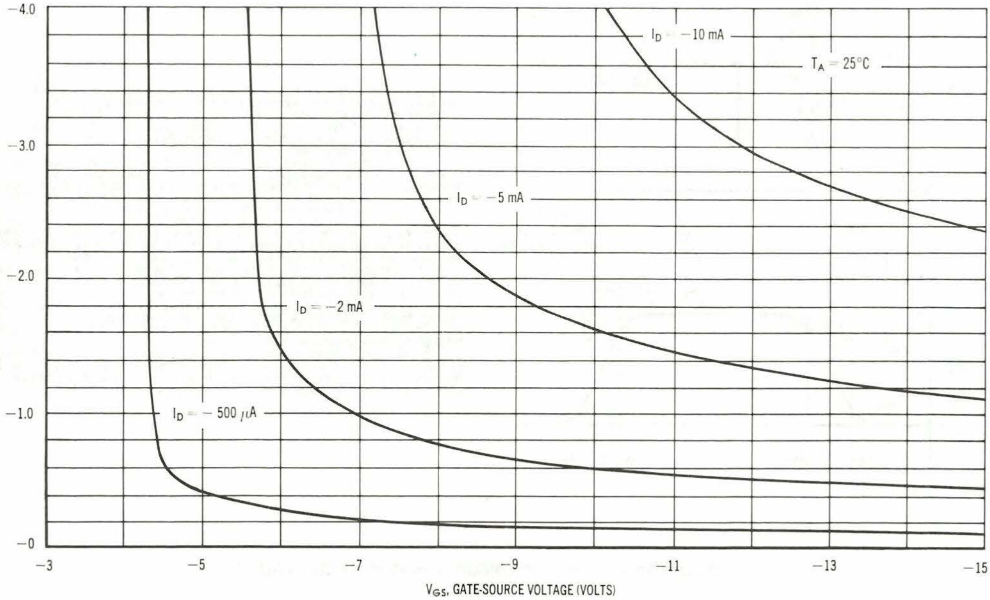


FIGURE 4 — "ON" DRAIN-SOURCE VOLTAGE



6

SWITCHING CHARACTERISTICS
($T_A = 25°C$)

FIGURE 5 — TURN-ON DELAY TIME

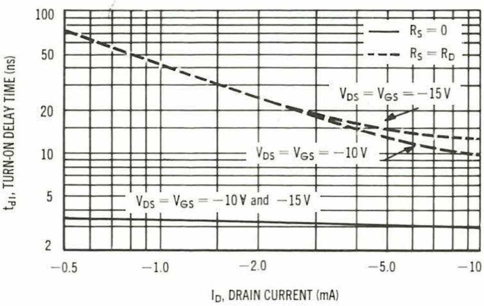


FIGURE 6 — RISE TIME

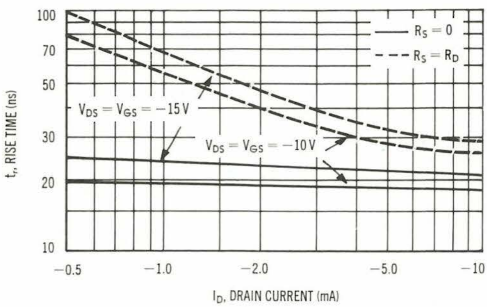


FIGURE 7 — TURN-OFF DELAY TIME

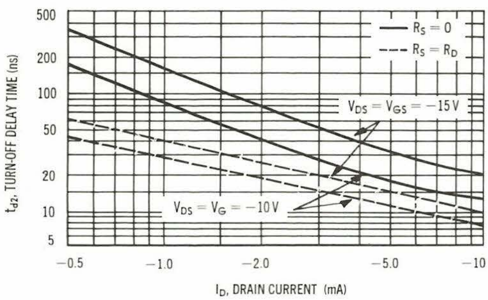


FIGURE 8 — FALL TIME

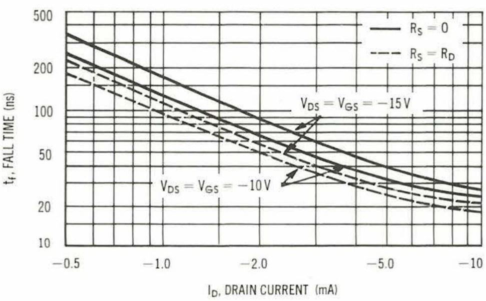
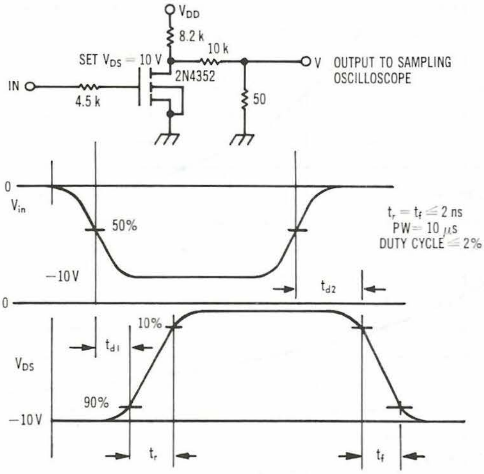


FIGURE 9 — SWITCHING CIRCUIT and WAVEFORMS



The switching characteristics shown above were measured in a test circuit similar to Figure 10. At the beginning of the switching interval, the gate voltage is at ground and the gate-source capacitance ($C_{gs} = C_{iss} - C_{rss}$) has no charge. The drain voltage is at V_{DD}, and thus the feedback capacitance (C_{rss}) is charged to V_{DD}. Similarly, the drain-substrate capacitance ($C_{d(sub)}$) is charged to V_{DD} since the substrate and source are connected to ground.

During the turn-on interval, C_{gs} is charged to V_{GS} (the input voltage) through R_S (generator impedance) (Figure 11). C_{rss} must be discharged to $V_{GS} - V_{D(on)}$ through R_S and the parallel combination of the load resistor (R_D) and the channel resistance (r_{ds}). In addition, $C_{d(sub)}$ is discharged to a low value ($V_{D(on)}$) through R_D in parallel with r_{ds}. During turn-off this charge flow is reversed.

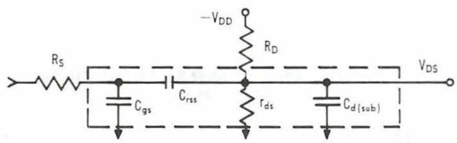
Predicting turn-on time proves to be somewhat difficult since the channel resistance (r_{ds}) is a function of the gate-source voltage (V_{GS}). As C_{gs} becomes charged V_{GS} is approaching V_{in} and r_{ds} decreases (see Figure 4) and since C_{rss} and $C_{d(sub)}$ are charged through r_{ds}, turn-on time is quite non-linear.

If the charging time of C_{gs} is short compared to that of C_{rss} and $C_{d(sub)}$, then r_{ds} (which is in parallel with R_D) will be low compared to R_D during the switching interval and will largely determine the turn-on time. On the other hand, during turn-off r_{ds} will be almost an open circuit requiring C_{rss} and $C_{d(sub)}$ to be charged through R_D and resulting in a turn-off time that is long compared to the turn-on time. This is especially noticeable for the curves where $R_S = 0$ and C_{gs} is charged through the pulse generator impedance only.

The switching curves shown with $R_S = R_D$ simulate the switching behavior of cascaded stages where the driving source impedance is normally the same as the load impedance. The set of curves with $R_S = 0$ simulates a low source impedance drive such as might occur in complementary logic circuits.

6

FIGURE 10 — SWITCHING CIRCUIT with MOSFET EQUIVALENT MODEL



2N4360

CASE 29-02, STYLE 7
TO-92 (TO-226AA)

JFET
LOW-FREQUENCY/LOW-NOISE

P-CHANNEL — DEPLETION

Refer to 2N5460 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	20	Vdc
Drain-Gate Voltage	V_{DG}	20	Vdc
Gate-Source Voltage	V_{GS}	20	Vdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	310 2.82	mW mW/°C
Storage Temperature Range	T_{stg}	−55 to +125	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 10\ \mu A$)	$V_{(BR)GSS}$	20	—	Vdc
Gate Reverse Current ($V_{GS} = 15$)	I_{GSS}	—	10	nA
Gate Source Cutoff Voltage ($V_{DS} = -10$ V, $I_D = 1.0\ \mu A$)	$V_{GS(off)}$	0.7	10.0	Vdc
Gate Source Voltage ($I_D = 0.3$ mA, $V_{DS} = -10$ V)	V_{GS}	0.4	9.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current ($V_{DS} = -10$ V, $V_{GS} = 0$ V)	I_{DSS}	3.0	30	mA
SMALL-SIGNAL CHARACTERISTICS				
Drain-Source "ON" Resistance ($I_D = 0$, $V_{GS} = 0$, f = 1.0 kHz)	r_{ds}	—	700	Ohms
Forward Transfer Admittance ($V_{DS} = -10$ V, $V_{GS} = 0$ V, f = 1.0 kHz)	$\|y_{fs}\|$	2000	8000	μmhos
Output Admittance ($V_{DS} = -10$ V, $V_{GS} = 0$ V, f = 1.0 kHz)	$\|y_{os}\|$	—	100	μmhos
Common Source Forward Transconductance ($V_{DS} = -10$ V, $V_{GS} = 0$ V, f = 1.0 MHz)	$Re(y_{fs})$	1500	—	μmhos
Input Capacitance ($V_{DS} = -10$ V, f = 1.0 MHz)	C_{iss}	—	20	pF
Reverse Transfer Capacitance ($V_{DS} = -10$ V, f = 1.0 MHz)	C_{rss}	—	5.0	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure ($V_{DS} = -10$ V, $I_D = 1.0$ mA, $R_G = 1.0$ mΩ, f = 100 Hz)	NF	—	5.0	dB

2N4391
2N4392
2N4393

CASE 22-03, STYLE 4
TO-18 (TO-206AA)

JFET
SWITCHING

N-CHANNEL — DEPLETION

Refer to MPF4391 for graphs.

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Gate-Source Voltage	V_{GS}	40	Vdc
Forward Gate Current	I_{GF}	50	mAdc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.8 10	Watts mW/°C
Operating Junction Temperature Range	T_J	−65 to +175	°C
Storage Temperature Range	T_{stg}	−65 to +175	°C

***ELECTRICAL CHARACTERISTICS** ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = 1.0\ \mu$Adc, $V_{DS} = 0$)		$V_{(BR)GSS}$	40	—	Vdc
Gate Reverse Current ($V_{GS} = 20$ Vdc, $V_{DS} = 0$) ($V_{GS} = 20$ Vdc, $V_{DS} = 0$, $T_A = 150°C$)		I_{GSS}	 — —	 0.1 0.2	nAdc μAdc
Gate Source Voltage ($V_{DS} = 20$ Vdc, $I_D = 1.0$ nAdc)	 2N4391 2N4392 2N4393	V_{GS}	 4.0 2.0 0.5	 10 5.0 3.0	Vdc
Gate-Source Forward Voltage ($I_G = 1.0$ mAdc, $V_{DS} = 0$)		$V_{GS(f)}$	—	1.0	Vdc
Drain-Cutoff Current ($V_{DS} = 20$ Vdc, $V_{GS} = 12$ Vdc) ($V_{DS} = 20$ Vdc, $V_{GS} = 7.0$ Vdc) ($V_{DS} = 20$ Vdc, $V_{GS} = 5.0$ Vdc) ($V_{DS} = 20$ Vdc, $V_{GS} = 12$ Vdc, $T_A = 150°C$) ($V_{DS} = 20$ Vdc, $V_{GS} = 7.0$ Vdc, $T_A = 150°C$) ($V_{DS} = 20$ Vdc, $V_{GS} = 5.0$ Vdc, $T_A = 150°C$)	 2N4391 2N4392 2N4393 2N4391 2N4392 2N4393	$I_{D(off)}$	 — — — — — —	 0.1 0.1 0.1 0.2 0.2 0.2	nAdc μAdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) ($V_{DS} = 20$ Vdc, $V_{GS} = 0$)	 2N4391 2N4392 2N4393	I_{DSS}	 50 25 5.0	 150 75 30	mAdc
Drain-Source On-Voltage ($I_D = 12$ mAdc, $V_{GS} = 0$) ($I_D = 6.0$ mAdc, $V_{GS} = 0$) ($I_D = 3.0$ mAdc, $V_{GS} = 0$)	 2N4391 2N4392 2N4393	$V_{DS(on)}$	 — — —	 0.4 0.4 0.4	Vdc
Static Drain-Source On Resistance ($I_D = 1.0$ mAdc, $V_{GS} = 0$)	 2N4391 2N4392 2N4393	$r_{DS(on)}$	 — — —	 30 60 100	Ohms
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance ($V_{GS} = 0$, $I_D = 0$, f = 1.0 kHz)	 2N4391 2N4392 2N4393	$r_{ds(on)}$	 — — —	 30 60 100	Ohms

*ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

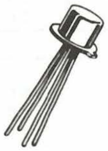
Characteristic		Symbol	Min	Max	Unit
Input Capacitance (V_{DS} = 20 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	14	pF
Reverse Transfer Capacitance		C_{rss}			pF
(V_{DS} = 0, V_{GS} = 12 Vdc, f = 1.0 MHz)	2N4391		—	3.5	
(V_{DS} = 0, V_{GS} = 7.0 Vdc, f = 1.0 MHz)	2N4392		—	3.5	
(V_{DS} = 0, V_{GS} = 5.0 Vdc, f = 1.0 MHz)	2N4393		—	3.5	
SWITCHING CHARACTERISTICS					
Rise Time		t_r			ns
($I_{D(on)}$ = 12 mAdc)	2N4391		—	5.0	
($I_{D(on)}$ = 6.0 mAdc)	2N4392		—	5.0	
($I_{D(on)}$ = 3.0 mAdc)	2N4393		—	5.0	
Fall Time		t_f			ns
($V_{GS(off)}$ = 12 Vdc)	2N4391		—	15	
($V_{GS(off)}$ = 7.0 Vdc)	2N4392		—	20	
($V_{GS(off)}$ = 5.0 Vdc)	2N4393		—	30	
Turn-On Time		t_{on}			ns
($I_{D(on)}$ = 12 mAdc)	2N4391		—	15	
($I_{D(on)}$ = 6.0 mAdc)	2N4392		—	15	
($I_{D(on)}$ = 3.0 mAdc)	2N4393		—	15	
Turn-Off Time		t_{off}			ns
($V_{GS(off)}$ = 12 Vdc)	2N4391		—	20	
($V_{GS(off)}$ = 7.0 Vdc)	2N4392		—	35	
($V_{GS(off)}$ = 5.0 Vdc)	2N4393		—	50	

(1) Pulse Test: Pulse Width ≤ 100 μs, Duty Cycle ≤ 1.0%.
*In addition to JEDEC Registered Data.

6

2N4416,A

CASE 20-03, STYLE 1
TO-72 (TO-206AF)



JFET
VHF/UHF AMPLIFIER

N-CHANNEL — DEPLETION

JAN JTX JTXV AVAILABLE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage 2N4416 2N4416A	V_{DG}	35 30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 1.71	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 1.0\ \mu$Adc, $V_{DS} = 0$) 2N4416 2N4416A	$V_{(BR)GSS}$	30 35	— —	Vdc
Gate Reverse Current ($V_{GS} = 20$ Vdc, $V_{DS} = 0$) ($V_{GS} = 20$ Vdc, $V_{DS} = 0$, $T_A = +150°C$)	I_{GSS}	— —	100 200	pAdc
Gate Source Cutoff Voltage ($I_D = 1.0$ nAdc, $V_{DS} = 15$ Vdc)	$V_{GS(off)}$	—	6.0	Vdc
Gate Source Voltage ($I_D = 0.5$ mAdc, $V_{DS} = 15$ Vdc)	V_{GS}	1.0	5.5	Vdc
Gate-Source Forward Voltage ($I_G = 1.0$ mAdc, $V_{DS} = 0$)	$V_{GS(f)}$	—	1.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current(1) ($V_{DS} = 15$ Vdc, $V_{GS} = 0$)	I_{DSS}	5.0	15	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance(1) ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)	$\|y_{fs}\|$	4500	7500	μmhos
Real Part of Forward Transfer Admittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 400 MHz)	$y_{fs(real)}$	4000	—	μmhos
Real Part of Input Admittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 100 MHz) ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 400 MHz)	$y_{is(real)}$	— —	100 1000	μmhos
Output Admittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)	$\|y_{os}\|$	—	50	μmhos
Real Part of Output Admittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 100 MHz) ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 400 MHz)	$y_{os(real)}$	— —	75 100	μmhos
Imaginary Part of Input Admittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 100 MHz) ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 400 MHz)	$y_{is(imag)}$	— —	2500 10,000	μmhos
Imaginary Part of Output Admittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 100 MHz) ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 400 MHz)	$y_{os(imag)}$	— —	1000 4000	μmhos

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	4.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	0.8	pF
Common Source Output Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	2.0	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure (Figures 3 and 4)	NF			dB
(V_{DS} = 15 Vdc, I_D = 5.0 mAdc, R_g ≈ 1000 Ohms, f = 100 MHz)		—	2.0	
(V_{DS} = 15 Vdc, I_D = 5.0 mAdc, R_g ≈ 1000 Ohms, f = 400 MHz)		—	4.0	
Small-Signal Power Gain Common Source (Figure 1)	G_{ps}			dB
(V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 100 MHz)		18	—	
(V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 400 MHz)		10	—	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

POWER GAIN

FIGURE 1 — EFFECTS OF DRAIN CURRENT

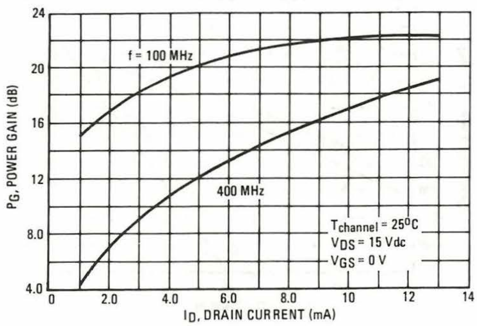
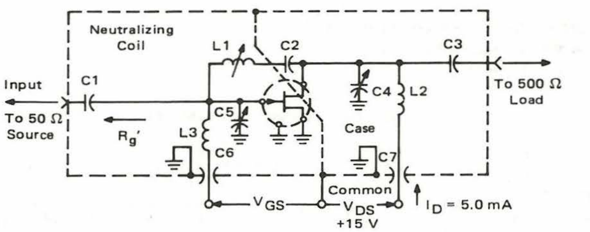


FIGURE 2 — 100 MHz and 400 MHz NEUTRALIZED TEST CIRCUIT



Adjust V_{GS} for I_D = 50 mA V_{GS} < 0 Volts

NOTE: The noise source is a hot-cold body (AIL type 70 or equivalent) with a test receiver (AIL type 136 or equivalent).

Reference Designation	VALUE 100 MHz	400 MHz
C1	7.0 pF	1.8 pF
C2	1000 pF	17 pF
C3	3.0 pF	1.0 pF
C4	1-12 pF	0.8-8.0 pF
C5	1-12 pF	0.8-8.0 pF
C6	0.0015 μF	0.001 μF
C7	0.0015 μF	0.001 μF
L1	3.0 μH*	0.2 μH**
L2	0.15 μH*	0.03 μH**
L3	0.14 μH*	0.022 μH**

*L1 17 turns, (approx. — depends upon circuit layout) AWG #28 enameled copper wire, close wound on 9/32" ceramic coil form. Tuning provided by a powdered iron slug.

L2 4-1/2 turns, AWG #18 enameled copper wire, 5/16" long, 3/8" I.D. (AIR CORE).

L3 3-1/2 turns, AWG #18 enameled copper wire, 1/4" long, 3/8" I.D. (AIR CORE).

**L1 6 turns, (approx. — depends upon circuit layout) AWG #24 enameled copper wire, close wound on 7/32" ceramic coil form. Tuning provided by an aluminum slug.

L2 1 turn, AWG #16 enameled copper wire, 3/8" I.D. (AIR CORE).

L3 1/2 turn, AWG #16 enameled copper wire, 1/4" I.D. (AIR CORE).

NOISE FIGURE

($T_{channel}$ = 25°C)

FIGURE 3 – EFFECTS OF DRAIN-SOURCE VOLTAGE

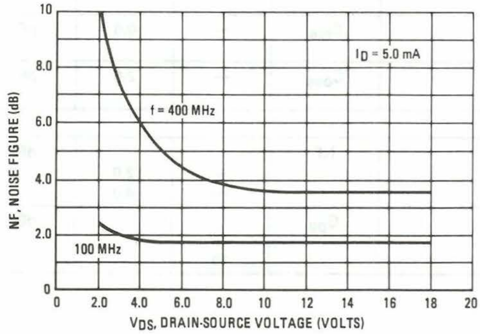
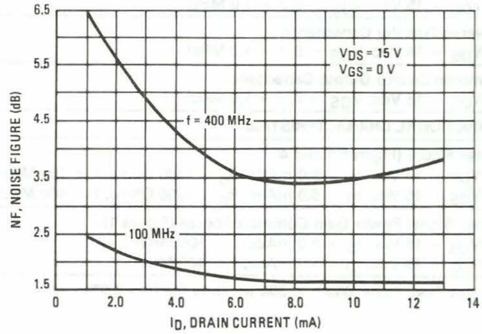
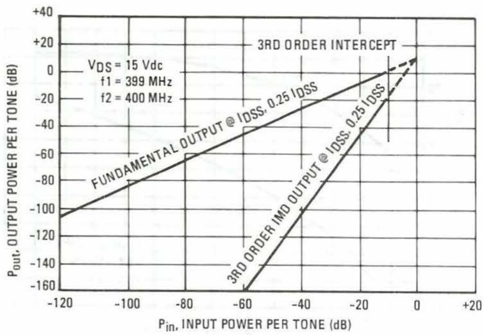


FIGURE 4 – EFFECTS OF DRAIN CURRENT



INTERMODULATION CHARACTERISTICS

FIGURE 5 – THIRD ORDER INTERMODULATION DISTORTION



COMMON SOURCE CHARACTERISTICS

ADMITTANCE PARAMETERS

(V_{DS} = 15 Vdc, $T_{channel}$ = 25°C)

FIGURE 6 – INPUT ADMITTANCE (y_{is})

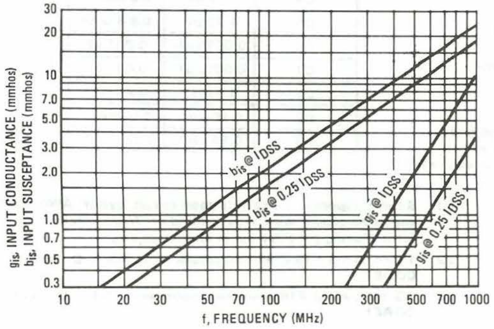


FIGURE 7 – REVERSE TRANSFER ADMITTANCE (y_{rs})

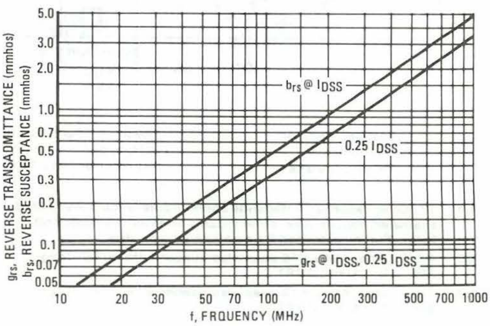


FIGURE 8 – FORWARD TRANSADMITTANCE (y_{fs})

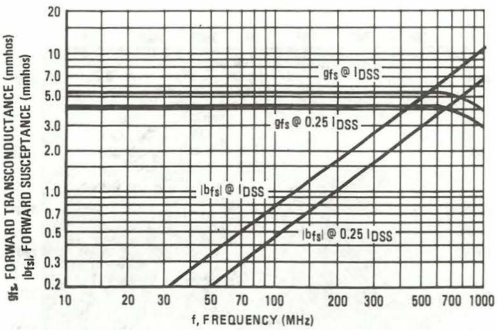
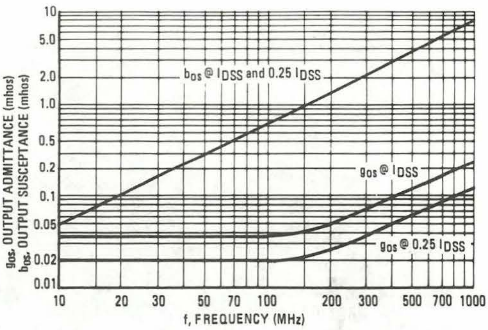


FIGURE 9 – OUTPUT ADMITTANCE (y_{os})



COMMON SOURCE CHARACTERISTICS

S-PARAMETERS

(V_{DS} = 15 Vdc, $T_{channel}$ = 25°C, Data Points in MHz)

FIGURE 10 – S_{11s}

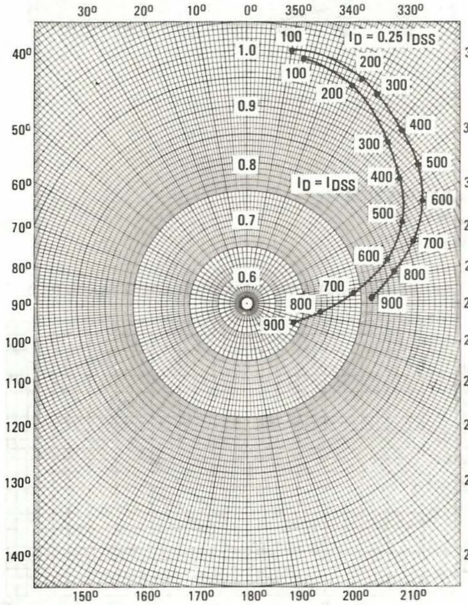
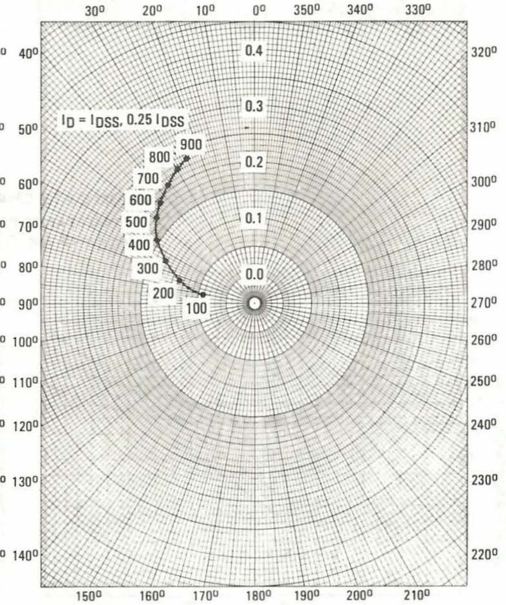


FIGURE 11 – S_{12s}



6

FIGURE 12 – S_{21s}

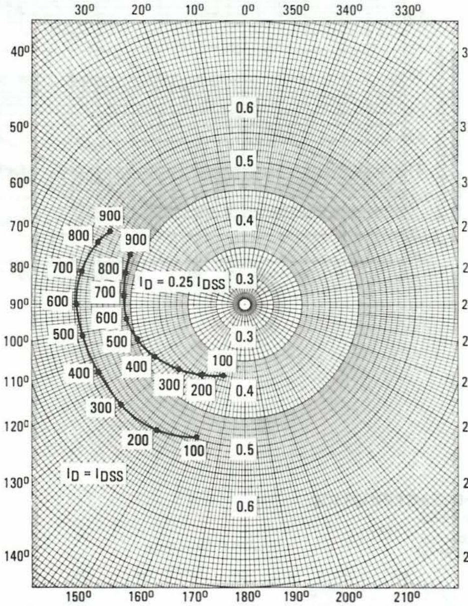
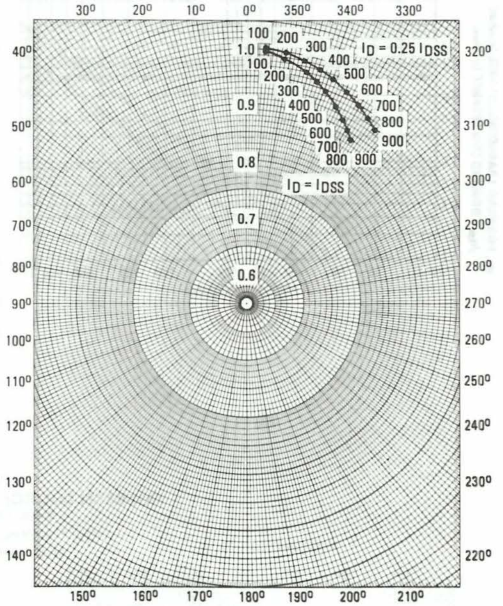


FIGURE 13 – S_{22s}



COMMON GATE CHARACTERISTICS

ADMITTANCE PARAMETERS

(V_{DG} = 15 Vdc, $T_{channel}$ = 25°C)

FIGURE 14 – INPUT ADMITTANCE (y_{ig})

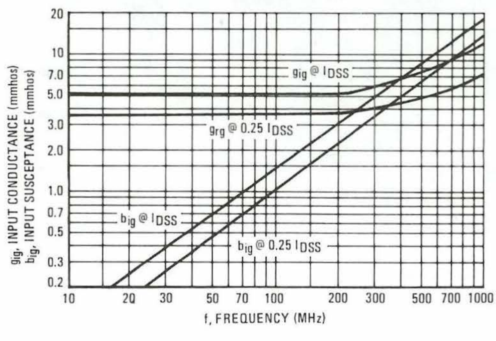


FIGURE 15 – REVERSE TRANSFER ADMITTANCE (y_{rg})

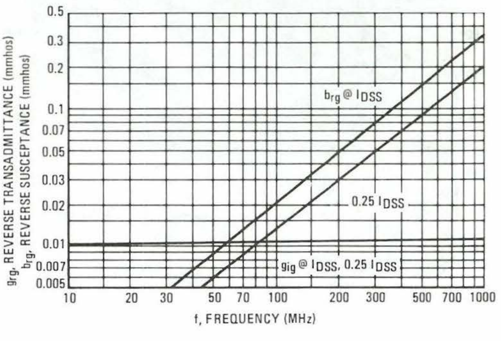


FIGURE 16 – FORWARD TRANSFER ADMITTANCE (y_{fg})

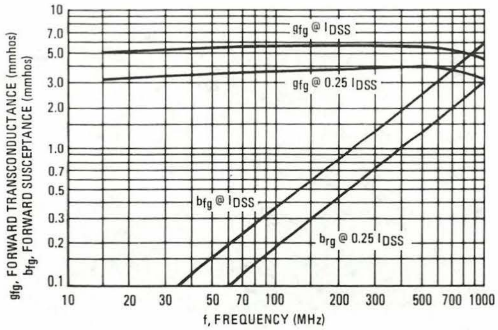
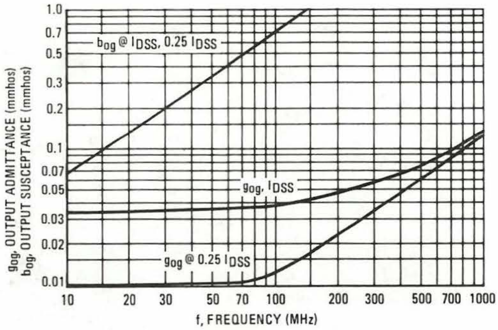


FIGURE 17 – OUTPUT ADMITTANCE (y_{og})



COMMON GATE CHARACTERISTICS

S-PARAMETERS

(V_{DG} = 15 Vdc, $T_{channel}$ = 25°C, Data Points in MHz)

FIGURE 18 – S_{11g}

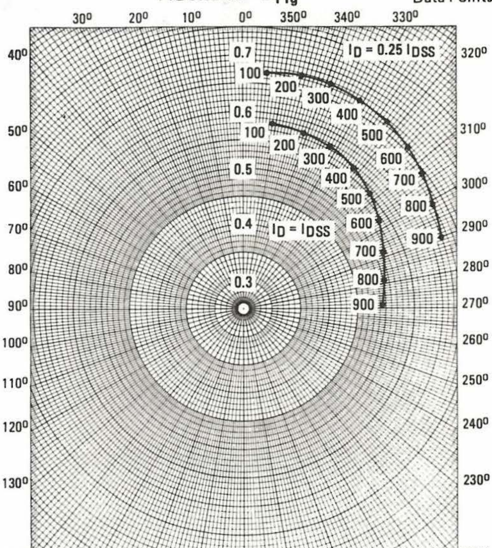


FIGURE 19 – S_{12g}

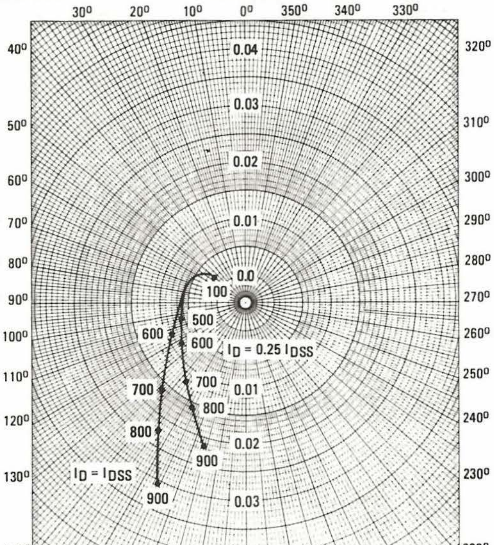


FIGURE 20 – S_{21g}

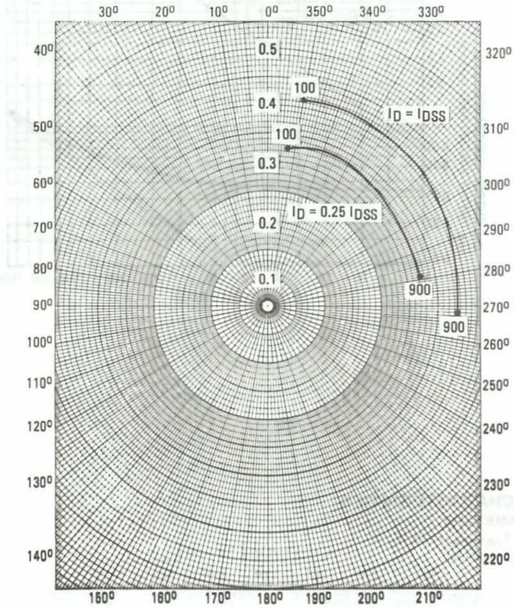
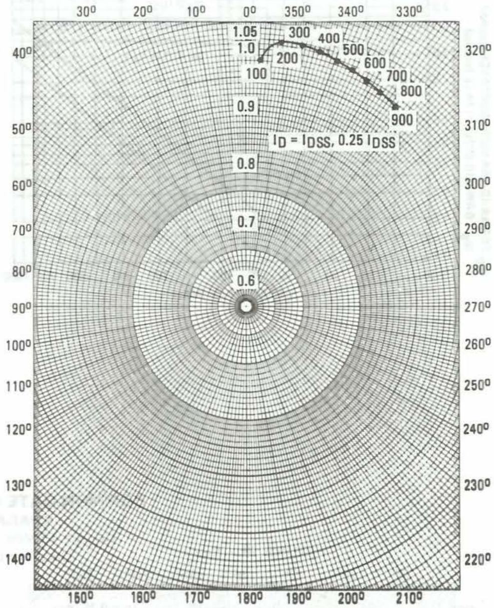


FIGURE 21 – S_{22g}



6

2N4856,A thru 2N4861,A

JAN, JTX AVAILABLE
CASE 22-03, STYLE 4
TO-18 (TO-206AA)

JFET SWITCHING

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	2N4856,A 2N4857,A 2N4858,A	2N4859,A 2N4860,A 2N4861,A	Unit
Drain-Source Voltage	V_{DS}	+40	+30	Vdc
Drain-Gate Voltage	V_{DG}	+40	+30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	−40	−30	Vdc
Forward Gate Current	I_{GF}	50		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	 360 2.4		 mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +175		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)	 2N4856,A, 2N4857,A, 2N4858,A 2N4859,A, 2N4860,A, 2N4861,A	$V_{(BR)GSS}$	 −40 −30	 — —	Vdc
Gate Reverse Current (V_{GS} = −20 Vdc, V_{DS} = 0) (V_{GS} = −15 Vdc, V_{DS} = 0) (V_{GS} = −20 Vdc, V_{DS} = 0, T_A = 150°C) (V_{GS} = −15 Vdc, V_{DS} = 0, T_A = 150°C)	 2N4856,A 2N4857,A, 2N4858,A 2N4859,A, 2N4860,A, 2N4861,A 2N4856,A, 2N4857,A, 2N4858,A 2N4859,A, 2N4860,A, 2N4861,A	I_{GSS}	 — — — —	 0.25 0.25 0.5 0.5	 nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 0.5 nAdc)	 2N4856,A, 2N4859,A 2N4857,A, 2N4860,A 2N4858,A, 2N4861,A	$V_{GS(off)}$	 −4.0 −2.0 −0.8	 −10 −6.0 −4.0	Vdc
Drain Cutoff Current (V_{DS} = 15 Vdc, V_{GS} = −10 Vdc) (V_{DS} = 15 Vdc, V_{GS} = −10 Vdc, T_A = 150°C)		$I_{D(off)}$	 — —	 0.25 0.5	 nAdc μAdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 15 Vdc, V_{GS} = 0)	 2N4856,A, 2N4859,A 2N4857,A, 2N4860,A 2N4858,A, 2N4861,A	I_{DSS}	 50 20 8.0	 — 100 80	mAdc
Drain-Source On-Voltage (I_D = 20 mAdc, V_{GS} = 0) (I_D = 10 mAdc, V_{GS} = 0) (I_D = 5.0 mAdc, V_{GS} = 0)	 2N4856,A, 2N4859,A 2N4857,A, 2N4860,A 2N4858,A, 2N4861,A	$V_{DS(on)}$	 — — —	 0.75 0.5 0.5	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	 2N4856,A, 2N4859,A 2N4857,A, 2N4860,A 2N4858,A, 2N4861,A	$r_{ds(on)}$	 — — —	 25 40 60	Ohms
Input Capacitance (V_{DS} = 0, V_{GS} = −10 Vdc, f = 1.0 MHz)	 2N4856 thru 2N4861 2N4856A thru 2N4861A	C_{iss}	 — —	 18 10	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = −10 Vdc, f = 1.0 MHz)	 2N4856 thru 2N4861 2N4856A, 2N4859A 2N4857A, 2N4858A, 2N4860A, 2N4861A	C_{rss}	 — — —	 8.0 4.0 3.5	pF

6

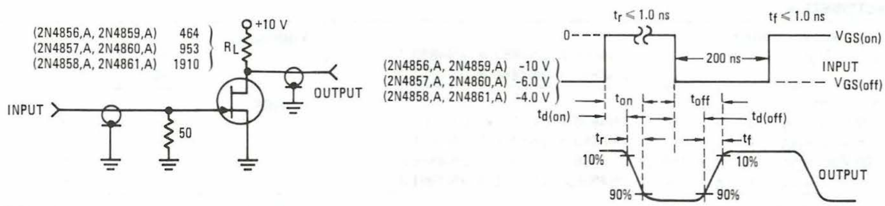
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic			Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS (See Figure 1) (2)						
Turn-On Delay Time	Conditions for 2N4856,A, 2N4859,A:	2N4856, 2N4859	$t_{d(on)}$	—	6.0	ns
		2N4856A, 2N4859A		—	5.0	
	(V_{DD} = 10 Vdc, $I_{D(on)}$ = 20 mAdc,	2N4857, 2N4860		—	6.0	
	$V_{GS(on)}$ = 0, $V_{GS(off)}$ = −10 Vdc)	2N4857A, 2N4860A		—	6.0	
		2N4858, 2N4861		—	10	
		2N4858A, 2N4861A		—	8.0	
Rise Time	Conditions for 2N4857,A, 2N4860,A:	2N4856,A, 2N4859,A	t_r	—	3.0	ns
		2N4857,A, 2N4860,A		—	4.0	
	(V_{DD} = 10 Vdc, $I_{D(on)}$ = 10 mAdc,	2N4858, 2N4861		—	10	
	$V_{GS(on)}$ = 0, $V_{GS(off)}$ = −6.0 Vdc)	2N4858A, 2N4861A		—	8.0	
Turn-Off Time		2N4856, 2N4859	t_{off}	—	25	
	Conditions for 2N4858,A, 2N4861,A:	2N4856A, 2N4859A		—	20	ns
		2N4857, 2N4860		—	50	
	(V_{DD} = 10 Vdc, $I_{D(on)}$ = 5.0 mAdc,	2N4857A, 2N4860A		—	40	
	$V_{GS(on)}$ = 0, $V_{GS(off)}$ = −4.0 Vdc)	2N4858, 2N4861		—	100	
		2N4858A; 2N4861A		—	80	

(1) Pulse Test: Pulse Width = 100 ms, Duty Cycle ≤ 10%.
(2) The $I_{D(on)}$ values are nominal; exact values vary slightly with transistor parameters.

6

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: Z_{out} = 50 ohms, Duty Cycle ≈ 2.0%.

b. Waveforms are monitored on an oscilloscope with the following characteristics: t_r ≤ 0.75 ns, R_{in} ≥ 1.0 megohm, C_{in} ≤ 2.5 pF.

2N5245
2N5246
2N5247

CASE 29-02, STYLE 23
TO-92 (TO-226AA)

JFET
HIGH-FREQUENCY
AMPLIFIER

N-CHANNEL — DEPLETION

Refer to 2N4416 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	−30	Vdc
Gate Current	I_G	50	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C (Free Air)	P_D	360 2.88	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	500 4.0	mW mW/°C
Lead Temperature (1/16" from Case for 10 Seconds)	T_L	260	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = −1.0 μA, V_{DS} = 0)		$V_{(BR)GSS}$	−30	—	Vdc
Gate Reverse Current (V_{GS} = −20 V, V_{DS} = 0)		I_{GSS}	—	−1.0	nA
Gate 1 Leakage Current (V_{G1S} = −20 V, V_{DS} = 0, T_A = 100°C)		I_{G1SS}	—	−0.5	μA
Gate Source Cutoff Voltage (V_{DS} = 15 V, I_D = 10 mA)	2N5245 2N5246 2N5247	$V_{GS(off)}$	−1.0 −0.5 −1.5	−6.0 −4.0 −8.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = 15 V, V_{GS} = 0, Pulsed: See Note 1)	2N5245 2N5246 2N5247	I_{DSS}	5.0 1.5 8.0	15 7.0 24	mA
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 kHz)	2N5245 2N5246 2N5247	$\|y_{fs}\|$	4500 3000 4500	7500 6000 8000	μmhos
Input Admittance (V_{DS} = 15 V, V_{GS} = 0)	(100 MHz) (400 MHz)	$Re(y_{is})$	— —	100 1000	μmhos
Output Admittance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 kHz)	2N5245 2N5246 2N5247	$\|y_{os}\|$	— — —	50 50 70	μmhos
Output Conductance (V_{DS} = 15 V, V_{GS} = 0)	2N5245 (100 MHz) 2N5246 2N5247 2N5245 (400 MHz) 2N5246 2N5247	$Re(y_{os})$	— — — — — —	75 75 100 100 100 150	μmhos

6

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Forward Transconductance (V_{DS} = 15 V, V_{GS} = 0, f = 400 MHz)	2N5245 2N5246 2N5247	$Re(y_{fs})$	4000 2500 4000	— — —	μmhos
Input Capacitance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 Mhz)		C_{iss}	—	4.5	pF
Reverse Transfer Capacitance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	1.0	pF
Input Susceptance (V_{DS} = 15 V, V_{GS} = 0)	(100 MHz) (400 MHz)	$I_M(Y_{is})$	— —	3.0 12.0	mmho

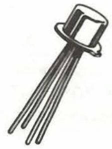
FUNCTIONAL CHARACTERISTICS

Characteristic		Symbol	Min	Max	Unit
Noise Figure (V_{DS} = 15 V, I_D = 5.0 mA, R'_G = 1.0 kΩ)		NF	— —	2.0 4.0	dB
Common Source Power Gain (V_{DS} = 15 V, I_D = 5.0 mA, R'_G = 1.0 kΩ)	2N5245 (100 MHz) 2N5245 (400 MHz)	G_{ps}	18 10	— —	dB
Output Susceptance (V_{DS} = 15 V, V_{GS} = 0)	(100 MHz) (400 MHz)	$I_M(Y_{os})$	— —	1000 4000	μmho

Note 1: tp = 100 ms, Duty Cycle = 10%.

2N5265 thru 2N5270

CASE 20-05, STYLE 5
TO-72 (TO-206AF)



JFET
GENERAL PURPOSE

P-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	60	Vdc
Drain-Gate Voltage	V_{DG}	60	Vdc
Reverse Gate-Source Voltage	V_{GSR}	60	Vdc
Drain Current	I_D	20	mAdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Junction Temperature Range	T_J	−65 to +175	°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	60	—	Vdc
Gate Reverse Current (V_{GS} = 30 Vdc, V_{DS} = 0) (V_{GS} = 30 Vdc, V_{DS} = 0, T_A = 150°C)		I_{GSS}	 — —	 2.0 2.0	 nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 1.0 μAdc)	 2N5265, 2N5266 2N5267, 2N5268 2N5269, 2N5270	$V_{GS(off)}$	 — — —	 3.0 6.0 8.0	Vdc
Gate Source Voltage (V_{DS} = 15 Vdc, I_D = 0.05 mAdc) (V_{DS} = 15 Vdc, I_D = 0.08 mAdc) (V_{DS} = 15 Vdc, I_D = 0.15 mAdc) (V_{DS} = 15 Vdc, I_D = 0.25 mAdc) (V_{DS} = 15 Vdc, I_D = 0.4 mAdc) (V_{DS} = 15 Vdc, I_D = 0.7 mAdc)	 2N5265 2N5266 2N5267 2N5268 2N5269 2N5270	V_{GS}	 0.3 0.4 1.0 1.0 2.0 2.0	 1.5 2.0 4.0 4.0 6.0 6.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	 2N5265 2N5266 2N5267 2N5268 2N5269 2N5270	I_{DSS}	 0.5 0.8 1.5 2.5 4.0 7.0	 1.0 1.6 3.0 5.0 8.0 14	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	 2N5265 2N5266 2N5267 2N5268 2N5269 2N5270	$\|y_{fs}\|$	 900 1000 1500 2000 2200 2500	 2700 3000 3500 4000 4500 5000	μmhos
Output Admittance Common Source (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)		$\|y_{os}\|$	—	75	μmhos

2N5265 thru 2N5270

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Common Source Forward Transconductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)		$Re(y_{fs})$			µmhos
	2N5265		800	—	
	2N5266		900	—	
	2N5267		1400	—	
	2N5268		1700	—	
	2N5269		1900	—	
	2N5270		2100	—	
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	2.0	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 M ohm, f = 100 Hz, BW = 1.0 Hz)		NF	—	2.5	dB
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 Hz, BW = 1.0 Hz)		e_n	—	115	$nV/\sqrt{Hz}$

6

FIGURE 1–6 TRANSFER CHARACTERISTIC CURVES FOR MIN/MAX I_{DSS} LIMITS

FIGURE 1

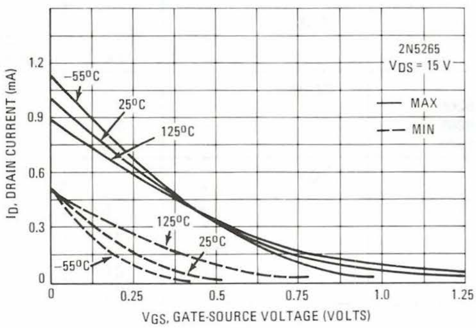


FIGURE 2

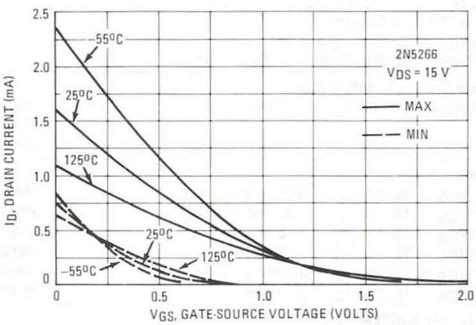


FIGURE 3

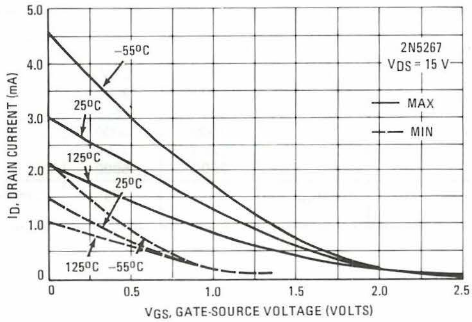


FIGURE 4

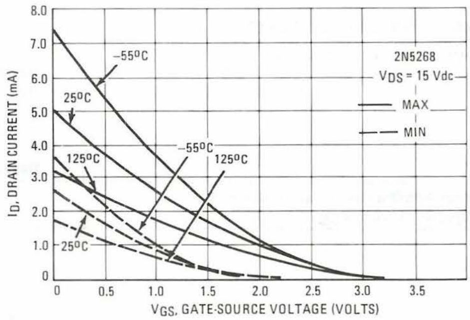


FIGURE 5

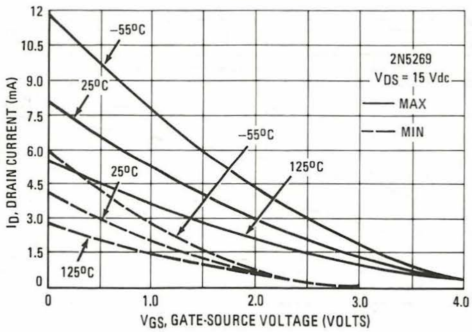
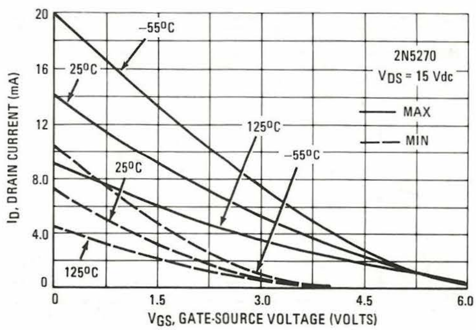


FIGURE 6



FIGURES 7-12 – TYPICAL AND MINIMUM FORWARD TRANSFER ADMITTANCE

FIGURE 7

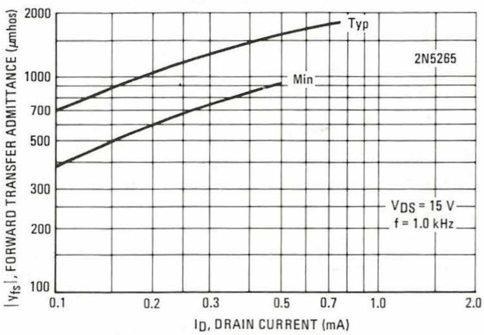
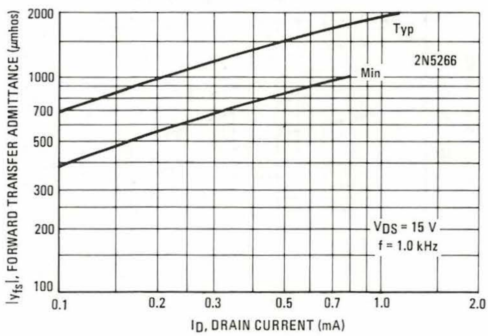


FIGURE 8



6

FIGURE 9

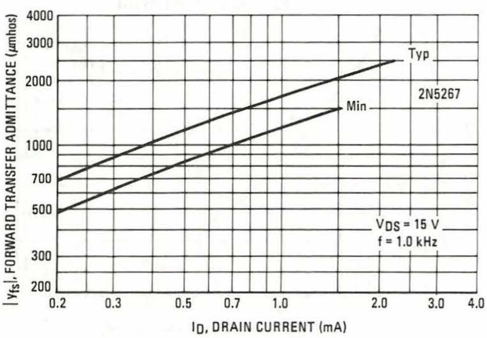


FIGURE 10

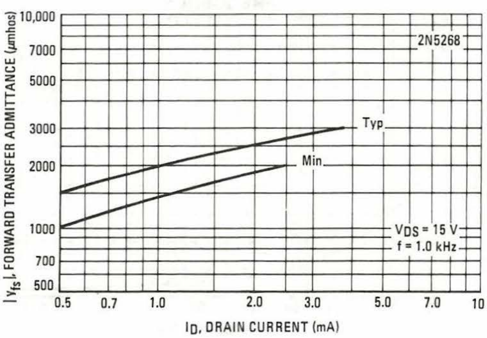


FIGURE 11

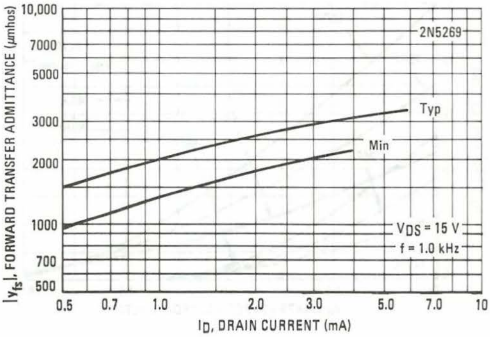
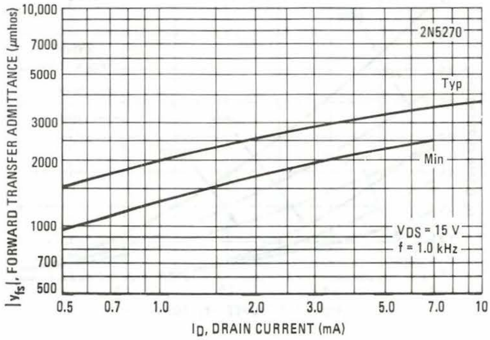


FIGURE 12



TYPICAL CURVES

FIGURE 13 – OUTPUT RESISTANCE versus DRAIN CURRENT

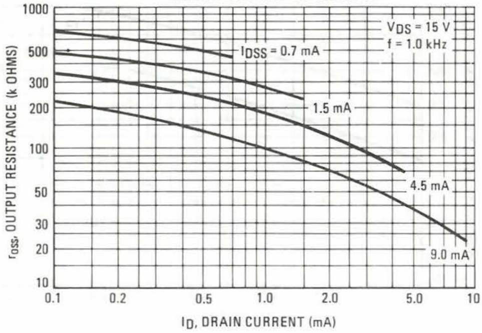


FIGURE 14 – CAPACITANCE versus DRAIN-SOURCE VOLTAGE

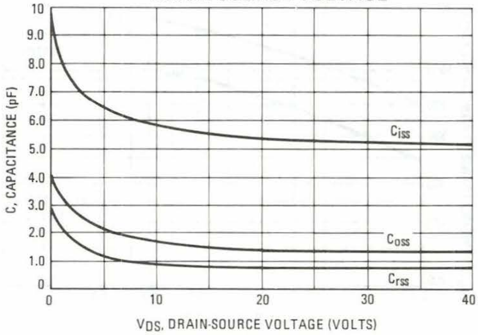


FIGURE 15 – NOISE FIGURE versus FREQUENCY

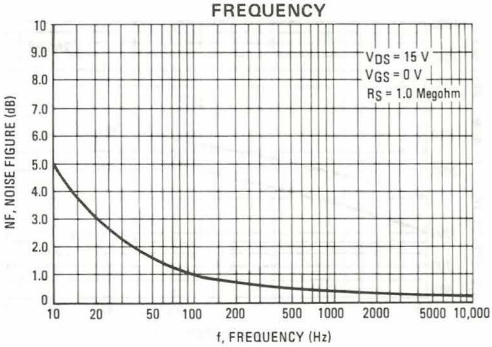


FIGURE 16 – NOISE FIGURE versus SOURCE RESISTANCE

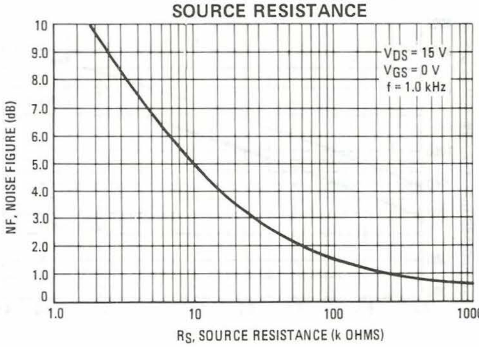


FIGURE 17 – DRAIN CURRENT TEMPERATURE COEFFICIENT versus DRAIN CURRENT

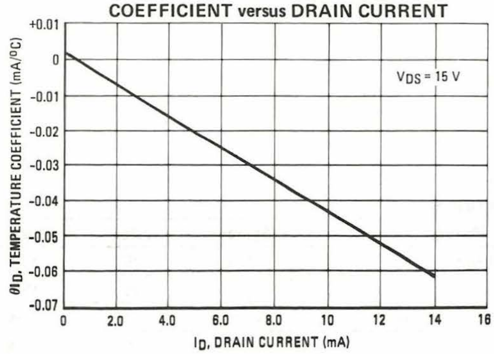
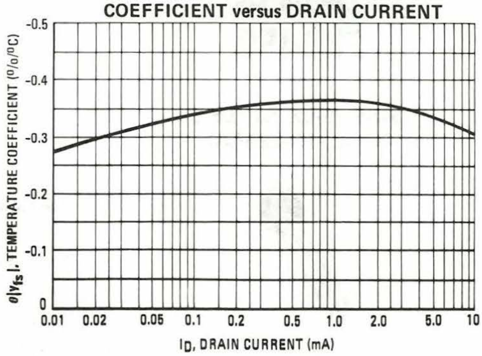


FIGURE 18 – FORWARD TRANSADMITTANCE COEFFICIENT versus DRAIN CURRENT



6

2N5457
2N5458
2N5459

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
GENERAL PURPOSE

N-CHANNEL — DEPLETION

Refer to 2N4220 for graphs.

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	−25	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Junction Temperature Range	T_J	125	°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = −10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	−25	—	—	Vdc
Gate Reverse Current (V_{GS} = −15 Vdc, V_{DS} = 0) (V_{GS} = −15 Vdc, V_{DS} = 0, T_A = 100°C)		I_{GSS}	 — —	 — —	 −1.0 −200	nAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	 2N5457 2N5458 2N5459	$V_{GS(off)}$	 −0.5 −1.0 −2.0	 — — —	 −6.0 −7.0 −8.0	Vdc
Gate Source Voltage (V_{DS} = 15 Vdc, I_D = 100 μAdc) (V_{DS} = 15 Vdc, I_D = 200 μAdc) (V_{DS} = 15 Vdc, I_D = 400 μAdc)	 2N5457 2N5458 2N5459	V_{GS}	 — — —	 −2.5 −3.5 −4.5	 — — —	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0)	 2N5457 2N5458 2N5459	I_{DSS}	 1.0 2.0 4.0	 3.0 6.0 9.0	 5.0 9.0 16	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance Common Source* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	 2N5457 2N5458 2N5459	$\|y_{fs}\|$	 1000 1500 2000	 — — —	 5000 5500 6000	μmhos
Output Admittance Common Source* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)		$\|y_{os}\|$	—	10	50	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	4.5	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	1.5	3.0	pF

*Pulse Test: Pulse Width ≤ 630 ms; Duty Cycle ≤ 10%.

2N5460 thru 2N5465

CASE 29-02, STYLE 7
TO-92 (TO-226AA)

JFET AMPLIFIER

P-CHANNEL — DEPLETION

6

MAXIMUM RATINGS

Rating	Symbol	2N5460 2N5461 2N5462	2N5463 2N5464 2N5465	Unit
Drain-Gate Voltage	V_{DG}	40	60	Vdc
Reverse Gate-Source Voltage	V_{GSR}	40	60	Vdc
Forward Gate Current	$I_{G(f)}$	10		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	310 2.82		mW mW/°C
Junction Temperature Range	T_J	−65 to +135		°C
Storage Channel Temperature Range	T_{stg}	−65 to +150		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage		$V_{(BR)GSS}$				Vdc
($I_G = 10\ \mu Adc$, $V_{DS} = 0$)	2N5460, 2N5461, 2N5462		40	—	—	
	2N5463, 2N5464, 2N5465		60	—	—	
Gate Reverse Current		I_{GSS}				
($V_{GS} = 20$ Vdc, $V_{DS} = 0$)	2N5460, 2N5461, 2N5462		—	—	5.0	nAdc
($V_{GS} = 30$ Vdc, $V_{DS} = 0$)	2N5463, 2N5464, 2N5465		—	—	5.0	
($V_{GS} = 20$ Vdc, $V_{DS} = 0$, $T_A = 100°C$)	2N5460, 2N5461, 2N5462		—	—	1.0	μAdc
($V_{GS} = 30$ Vdc, $V_{DS} = 0$, $T_A = 100°C$)	2N5463, 2N5464, 2N5465		—	—	1.0	
Gate Source Cutoff Voltage		$V_{GS(off)}$				Vdc
($V_{DS} = 15$ Vdc, $I_D = 1.0\ \mu Adc$)	2N5460, 2N5463		0.75	—	6.0	
	2N5461, 2N5464		1.0	—	7.5	
	2N5462, 2N5465		1.8	—	9.0	
Gate Source Voltage		V_{GS}				Vdc
($V_{DS} = 15$ Vdc, $I_D = 0.1$ mAdc)	2N5460, 2N5463		0.5	—	4.0	
($V_{DS} = 15$ Vdc, $I_D = 0.2$ mAdc)	2N5461, 2N5464		0.8	—	4.5	
($V_{DS} = 15$ Vdc, $I_D = 0.4$ mAdc)	2N5462, 2N5465		1.5	—	6.0	
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current		I_{DSS}				mAdc
($V_{DS} = 15$ Vdc, $V_{GS} = 0$,	2N5460, 2N5463		1.0	—	5.0	
f = 1.0 kHz)	2N5461, 2N5464		2.0	—	9.0	
	2N5462, 2N5465		4.0	—	16	
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance		$\|y_{fs}\|$				μmhos
($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)	2N5460, 2N5463		1000	—	4000	
	2N5461, 2N5464		1500	—	5000	
	2N5462, 2N5465		2000	—	6000	
Output Admittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)		$\|y_{os}\|$	—	—	75	μmhos
Input Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)		C_{iss}	—	5.0	7.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)		C_{rss}	—	1.0	2.0	pF
FUNCTIONAL CHARACTERISTICS						
Noise Figure ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, $R_G = 1.0$ Megohm, f = 100 Hz, BW = 1.0 Hz)		NF	—	1.0	2.5	dB
Equivalent Short-Circuit Input Noise Voltage ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 100 Hz, BW = 1.0 Hz)		e_n	—	60	115	$nV/\sqrt{Hz}$

DRAIN CURRENT versus GATE SOURCE VOLTAGE

FIGURE 1 — $V_{GS(off)}$ = 2.0 VOLTS

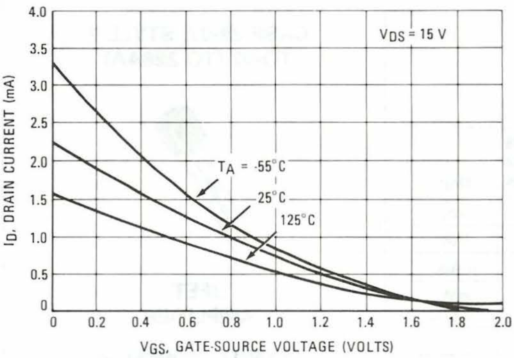


FIGURE 2 — $V_{GS(off)}$ = 4.0 VOLTS

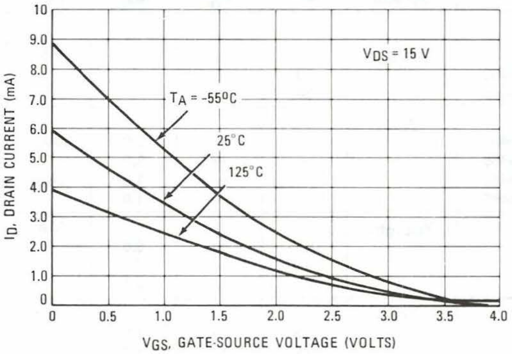
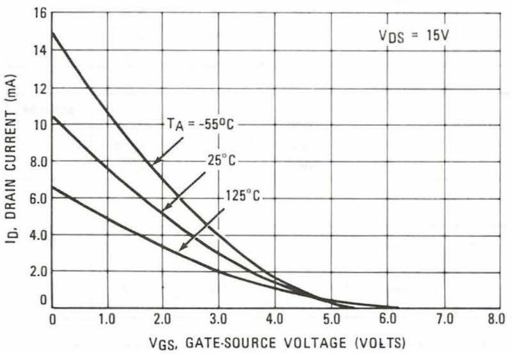


FIGURE 3 — $V_{GS(off)}$ = 5.0 VOLTS



FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

FIGURE 4 — $V_{GS(off)}$ = 2.0 VOLTS

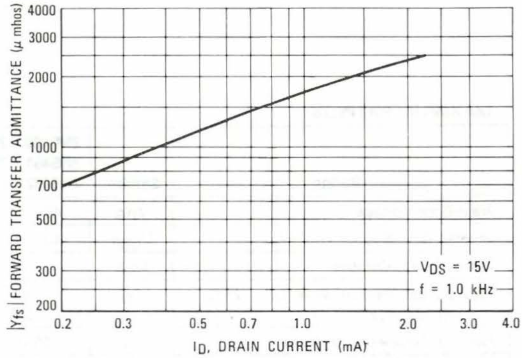


FIGURE 5 — $V_{GS(off)}$ = 4.0 VOLTS

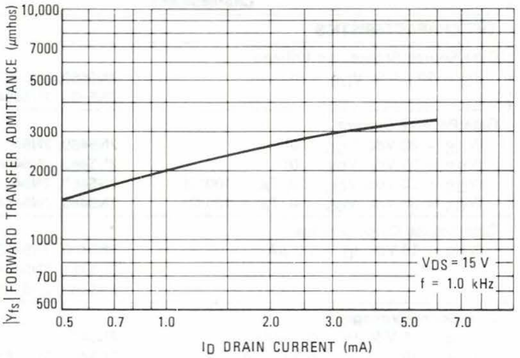
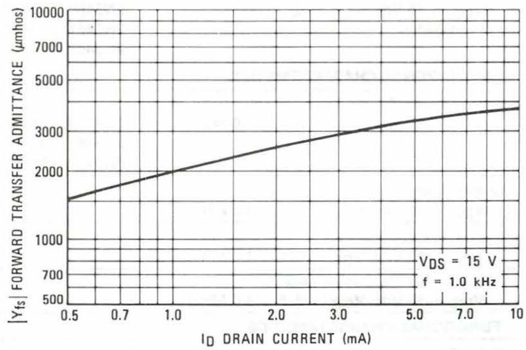


FIGURE 6 — $V_{GS(off)}$ = 5.0 VOLTS



6

FIGURE 7 — OUTPUT RESISTANCE VERSUS DRAIN CURRENT

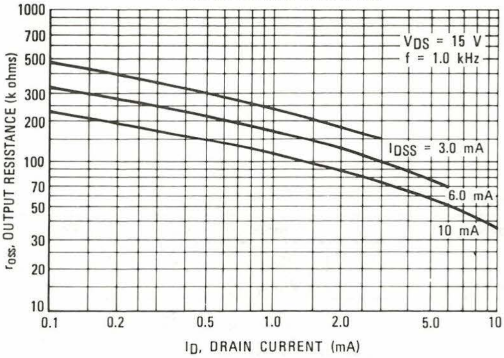


FIGURE 8 — CAPACITANCE VERSUS DRAIN-SOURCE VOLTAGE

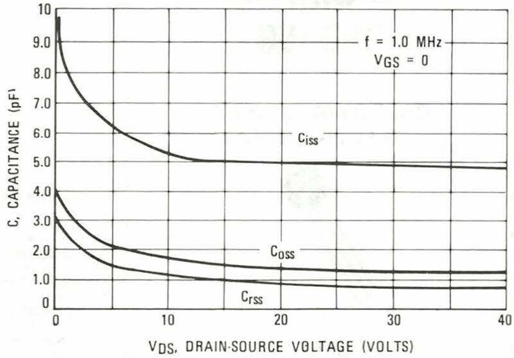


FIGURE 9 — NOISE FIGURE VERSUS FREQUENCY

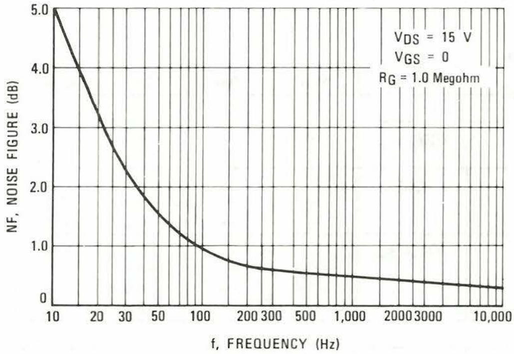


FIGURE 10 — NOISE FIGURE VERSUS SOURCE RESISTANCE

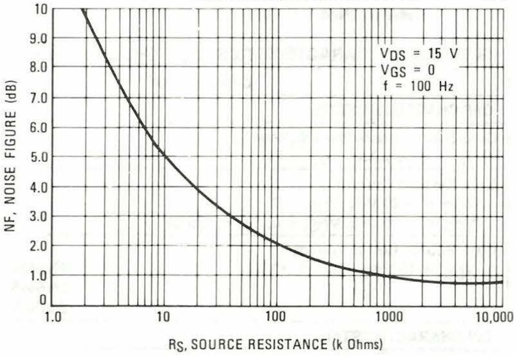
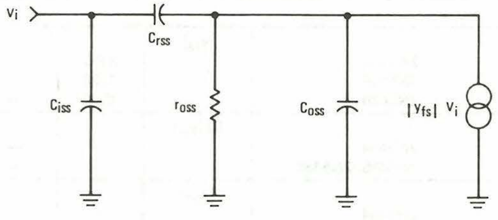


FIGURE 11 — EQUIVALENT LOW FREQUENCY CIRCUIT



Common Source
y Parameters for Frequencies
Below 30 MHz

$y_{is} = j\omega C_{iss}$

$y_{os} = j\omega C_{osp}{}^* + 1/r_{oss}$

$y_{fs} = |y_{fs}|$

$y_{rs} = -j\omega C_{rss}$

*C_{osp} is C_{oss} in parallel with Series Combination of C_{iss} and C_{rss}.

NOTE:

1. Graphical data is presented for dc conditions. Tabular data is given for pulsed conditions (Pulse Width = 630 ms, Duty Cycle = 10%).

2N5484 thru 2N5486

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
VHF/UHF AMPLIFIER

N-CHANNEL — DEPLETION

Refer to 2N4416 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	25	Vdc
Drain Current	I_D	30	mAdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150	°C

6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = −1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	−25	—	—	Vdc
Gate Reverse Current (V_{GS} = −20 Vdc, V_{DS} = 0) (V_{GS} = −20 Vdc, V_{DS} = 0, T_A = 100°C)		I_{GSS}	 — —	 — —	 −1.0 −0.2	 nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	 2N5484 2N5485 2N5486	$V_{GS(off)}$	 −0.3 −0.5 −2.0	 — — —	 −3.0 −4.0 −6.0	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	 2N5484 2N5485 2N5486	I_{DSS}	 1.0 4.0 8.0	 — — —	 5.0 10 20	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	 2N5484 2N5485 2N5486	$\|y_{fs}\|$	 3000 3500 4000	 — — —	 6000 7000 8000	μmhos
Input Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)	 2N5484 2N5485, 2N5486	$Re(y_{is})$	 — —	 — —	 100 1000	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	 2N5484 2N5485 2N5486	$\|y_{os}\|$	 — — —	 — — —	 50 60 75	μmhos
Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)	 2N5484 2N5485, 2N5486	$Re(y_{os})$	 — —	 — —	 75 100	μmhos
Forward Transconductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)	 2N5484 2N5485 2N5486	$Re(y_{fs})$	 2500 3000 3500	 — — —	 — — —	μmhos

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	—	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	—	1.0	pF
Output Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{oss}	—	—	2.0	pF
FUNCTIONAL CHARACTERISTICS						
Noise Figure		NF				dB
(V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 Megohm, f = 1.0 kHz)			—	—	2.5	
(V_{DS} = 15 Vdc, I_D = 1.0 mAdc, $R_G \approx$ 1.0 k ohm, f = 100 MHz)	2N5484		—	—	3.0	
(V_{DS} = 15 Vdc, I_D = 1.0 mAdc, $R_G \approx$ 1.0 k ohm, f = 200 MHz)	2N5484		—	4.0	—	
(V_{DS} = 15 Vdc, I_D = 4.0 mAdc, $R_G \approx$ 1.0 k ohm, f = 100 MHz)	2N5485, 2N5486		—	—	2.0	
(V_{DS} = 15 Vdc, I_D = 4.0 mAdc, $R_G \approx$ 1.0 k ohm, f = 400 MHz)	2N5485, 2N5486		—	—	4.0	
Common Source Power Gain		G_{ps}				dB
(V_{DS} = 15 Vdc, I_D = 1.0 mAdc, f = 100 MHz)	2N5484		16	—	25	
(V_{DS} = 15 Vdc, I_D = 1.0 mAdc, f = 200 MHz)	2N5484		—	14	—	
(V_{DS} = 15 Vdc, I_D = 4.0 mAdc, f = 100 MHz)	2N5485, 2N5486		18	—	30	
(V_{DS} = 15 Vdc, I_D = 4.0 mAdc, f = 400 MHz)	2N5485, 2N5486		10	—	20	

6

2N5555

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
SWITCHING

N-CHANNEL — DEPLETION

6

MAXIMUM RATINGS

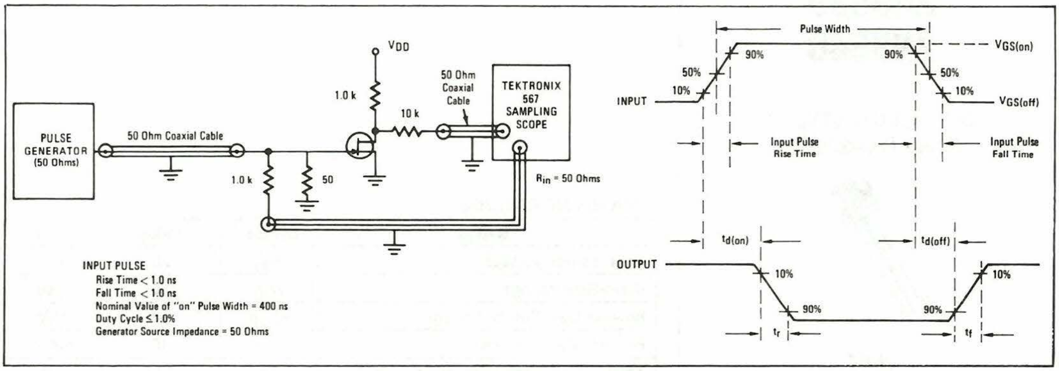
Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	310 2.82	mW mW/°C
Junction Temperature Range	T_J	−65 to +150	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 10\ \mu$Adc, $V_{DS} = 0$)	$V_{(BR)GSS}$	25	—	Vdc
Gate Reverse Current ($V_{GS} = 15$ Vdc, $V_{DS} = 0$)	I_{GSS}	—	1.0	nAdc
Drain Cutoff Current ($V_{DS} = 12$ Vdc, $V_{GS} = -10$ V) ($V_{DS} = 12$ Vdc, $V_{GS} = -10$ V, $T_A = 100°C$)	$I_{D(off)}$	 — —	 10 2.0	nAdc μAdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current* ($V_{DS} = 15$ Vdc, $V_{GS} = 0$)	I_{DSS}	15	—	mAdc
Gate-Source Forward Voltage ($I_{G(f)} = 1.0$ mAdc, $V_{DS} = 0$)	$V_{GS(f)}$	—	1.0	Vdc
Drain-Source On-Voltage ($I_D = 7.0$ mAdc, $V_{GS} = 0$)	$V_{DS(on)}$	—	1.5	Vdc
Static Drain-Source On Resistance ($I_D = 0.1$ mAdc, $V_{GS} = 0$)	$r_{DS(on)}$	—	150	Ohms
SMALL-SIGNAL CHARACTERISTICS				
Small-Signal Drain-Source "ON" Resistance ($V_{GS} = 0$, $I_D = 0$, f = 1.0 kHz)	$r_{ds(on)}$	—	150	Ohms
Input Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)	C_{iss}	—	5.0	pF
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = 10$ Vdc, f = 1.0 MHz)	C_{rss}	—	1.2	pF
SWITCHING CHARACTERISTICS				
Turn-On Delay Time — ($V_{DD} = 10$ Vdc, $I_{D(on)} = 7.0$ mAdc,	$t_{d(on)}$	—	5.0	ns
Rise Time — $V_{GS(on)} = 0$, $V_{GS(off)} = -10$ Vdc) (See Figure 1)	t_r	—	5.0	ns
Turn-Off Delay Time — ($V_{DD} = 10$ Vdc, $I_{D(on)} = 7.0$ mAdc,	$t_{d(off)}$	—	15	ns
Fall Time — $V_{GS(on)} = 0$, $V_{GS(off)} = -10$ Vdc) (See Figure 1)	t_f	—	10	ns

*Pulse Test: Pulse Width < 300 μs, Duty Cycle < 3.0%.

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT



2N5638
2N5639
2N5640

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
SWITCHING

N-CHANNEL — DEPLETION

Refer to 2N5653 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	30	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Junction Temperature Range	T_J	−65 to +150	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current (V_{GS} = −15 Vdc, V_{DS} = 0) (V_{GS} = −15 Vdc, V_{DS} = 0, T_A = 100°C)		I_{GSS}	 — —	 1.0 1.0	 nAdc μAdc
Drain Cutoff Current (V_{DS} = 15 Vdc, V_{GS} = −12 Vdc) (V_{DS} = 15 Vdc, V_{GS} = −8.0 Vdc) (V_{DS} = 15 Vdc, V_{GS} = −6.0 Vdc) (V_{DS} = 15 Vdc, V_{GS} = −12 Vdc, T_A = 100°C) (V_{DS} = 15 Vdc, V_{GS} = −8.0 Vdc, T_A = 100°C) (V_{DS} = 15 Vdc, V_{GS} = −6.0 Vdc, T_A = 100°C)	 2N5638 2N5639 2N5640 2N5638 2N5639 2N5640	$I_{D(off)}$	 — — — — — —	 1.0 1.0 1.0 1.0 1.0 1.0	 nAdc μAdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 20 Vdc, V_{GS} = 0)	 2N5638 2N5639 2N5640	I_{DSS}	 50 25 5.0	 — — —	mAdc
Drain-Source On-Voltage (I_D = 12 mAdc, V_{GS} = 0) (I_D = 6.0 mAdc, V_{GS} = 0) (I_D = 3.0 mAdc, V_{GS} = 0)	 2N5638 2N5639 2N5640	$V_{DS(on)}$	 — — —	 0.5 0.5 0.5	Vdc
Static Drain-Source On Resistance (I_D = 1.0 mAdc, V_{GS} = 0)	 2N5638 2N5639 2N5640	$r_{DS(on)}$	 — — —	 30 60 100	Ohms
SMALL-SIGNAL CHARACTERISTICS					
Static Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	 2N5638 2N5639 2N5640	$r_{ds(on)}$	 — — —	 30 60 100	Ohms
Input Capacitance (V_{DS} = 0, V_{GS} = −12 Vdc, f = 1.0 MHz)		C_{iss}	—	10	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = −12 Vdc, f = 1.0 MHz)		C_{rss}	—	4.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic				Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS							
Turn-On Delay Time	V_{DD} = 10 Vdc, $V_{GS(on)}$ = 0, $V_{GS(off)}$ = −10 Vdc, R_G' = 50 ohms	$I_{D(on)}$ = 12 mAdc	2N5638	$t_{d(on)}$	—	4.0	ns
		6.0 mAdc	2N5639		—	6.0	
		3.0 mAdc	2N5640		—	8.0	
Rise Time		$I_{D(on)}$ = 12 mAdc	2N5638	t_r	—	5.0	ns
		6.0 mAdc	2N5639		—	8.0	
		3.0 mAdc	2N5640		—	10	
Turn-Off Delay Time		$I_{D(on)}$ = 12 mAdc	2N5638	$t_{d(off)}$	—	5.0	ns
		6.0 mAdc	2N5639		—	10	
		3.0 mAdc	2N5640		—	15	
Fall Time		$I_{D(on)}$ = 12 mAdc	2N5638	t_f	—	10	ns
		6.0 mAdc	2N5639		—	20	
		3.0 mAdc	2N5640		—	30	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 3.0%.

6

2N5653
2N5654

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
SWITCHING

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	30	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

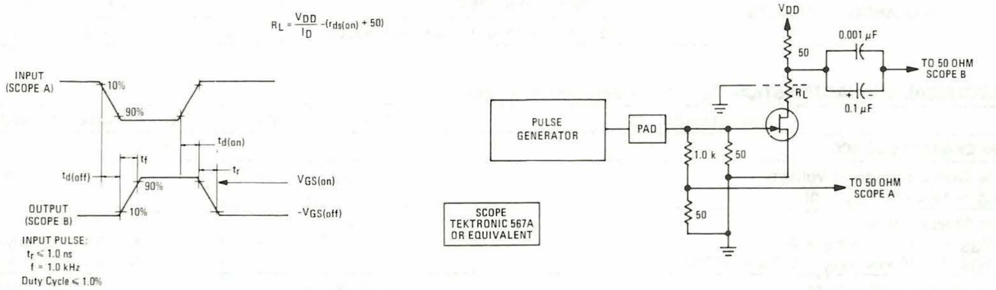
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current (V_{GS} = −15 Vdc, V_{DS} = 0) (V_{GS} = −15 Vdc, V_{DS} = 0, T_A = 100°C)		I_{GSS}	 — —	 1.0 1.0	 nAdc μAdc
Drain Cutoff Current (V_{DS} = 15 Vdc, V_{GS} = −12 Vdc) (V_{DS} = 15 Vdc, V_{GS} = −8.0 Vdc) (V_{DS} = 15 Vdc, V_{GS} = −12 Vdc, T_A = 100°C) (V_{DS} = 15 Vdc, V_{GS} = −8.0 Vdc, T_A = 100°C)	 2N5653 2N5654 2N5653 2N5654	$I_{D(off)}$	 — — — —	 1.0 1.0 1.0 1.0	 nAdc μAdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 20 Vdc, V_{GS} = 0)	 2N5653 2N5654	I_{DSS}	 40 15	 — —	mAdc
Drain-Source On-Voltage (I_D = 10 mAdc, V_{GS} = 0) (I_D = 5.0 mAdc, V_{GS} = 0)	 2N5653 2N5654	$V_{DS(on)}$	 — —	 0.75 0.75	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Static Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 1.0 mAdc) (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	 2N5653 2N5654 2N5653 2N5654	$r_{ds(on)}$	 — — — —	 50 100 50 100	Ohms
Input Capacitance (V_{DS} = 0, V_{GS} = −12 Vdc, f = 1.0 MHz)		C_{iss}	—	10	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = −12 Vdc, f = 1.0 MHz) (V_{DS} = 0, V_{GS} = −8.0 Vdc, f = 1.0 MHz)	 2N5653 2N5653	C_{rss}	 — —	 3.5 3.5	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic			Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS						
Turn-On Delay Time	Test Condition for 2N5653: (V_{DD} = 10 Vdc, $V_{GS(on)}$ = 0, $V_{GS(off)}$ = −12 Vdc, $I_{D(on)}$ = 10 mAdc, R_G' = 50 Ohms)	2N5653 2N5654	$t_{d(on)}$	— —	4.0 6.0	ns
Rise Time		2N5653 2N5654	t_r	— —	5.0 8.0	ns
Turn-Off Delay Time	Test Condition for 2N5654: (V_{DD} = 10 Vdc, $V_{GS(on)}$ = 0, $V_{GS(off)}$ = −12 Vdc, $I_{D(on)}$ = 5.0 mAdc, R_G' = 50 Ohms) (Figure 1)	2N5653 2N5654	$t_{d(off)}$	— —	5.0 10	ns
Fall Time		2N5653 2N5654	t_f	— —	10 20	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 3.0%.

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



6

2N5668
2N5669
2N5670

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
VHF AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	25	Vdc
Drain Current	I_D	20	mAdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

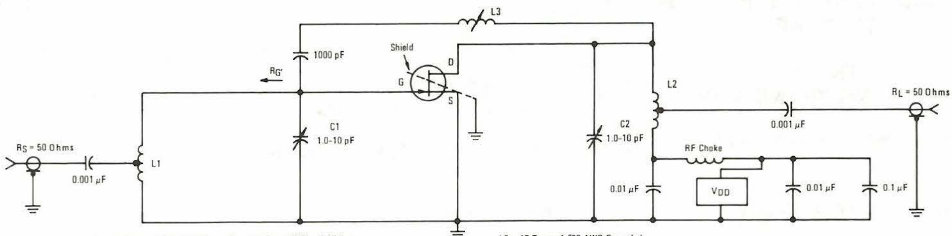
Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	25	—	—	Vdc
Gate Reverse Current (V_{GS} = −15 Vdc, V_{DS} = 0) (V_{GS} = −15 Vdc, V_{DS} = 0, T_A = 100°C)		I_{GSS}	 — —	 — —	 2.0 2.0	 nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	 2N5668 2N5669 2N5670	$V_{GS(off)}$	 0.2 1.0 2.0	 — — —	 4.0 6.0 8.0	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 15 Vdc, V_{GS} = 0)	 2N5668 2N5669 2N5670	I_{DSS}	 1.0 4.0 8.0	 — — —	 5.0 10 20	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	 2N5668 2N5669 2N5670	$\|y_{fs}\|$	 1500 2000 3000	 — — —	 6500 6500 7500	μmhos
Input Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)		$Re(y_{is})$	—	125	800	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	 2N5668 2N5669 2N5670	$\|y_{os}\|$	 — — —	 — — —	 20 50 75	μmhos
Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	 2N5668 2N5669 2N5670	$Re(y_{os})$	 — — —	 10 25 35	 50 100 150	μmhos
Forward Transconductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	 2N5668 2N5669 2N5670	$Re(y_{fs})$	 1000 1600 2500	 — — —	 — — —	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	4.7	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	1.0	3.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Output Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	1.4	4.0	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (Figure 1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz at R_G' = 1.0 k ohm)	NF	—	—	2.5	dB
Common Source Power Gain (Figure 1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	G_{ps}	16	—	—	dB

(1) Pulse Test: Pulse Width = 100 ms, Duty Cycle ≤ 10%.

FIGURE 1 — 100 MHz, POWER GAIN AND NOISE FIGURE TEST CIRCUIT



L1 ≈ 8.5 Turns of #14 AWG Tinned Copper; Dia. ≈ 3/8", ≈ 0.9" Long. Tapped at ≈ 2-1/2 Turns (adjust to give R_G = 1.0 k ohm); Parallel Resistance = 40 k ohms; tunes at ≈ 8.0 pF.

L2 ≈ 13.5 Turns #16 AWG Tinned Copper; Dia. ≈ 3/8", ≈ 1.2" Long. Tapped at ≈ 5 Turns; Parallel Resistance = 40 k ohms; tunes at ≈ 4.0 pF.

L3 ≈ 17 Turns of #28 AWG Enameled Copper Wire, Close Wound on 9/32" Ceramic Form, Tuning Provided by a Powdered Iron Slug.

6

2N6659
2N6660
2N6661
MPF6659
MPF6660
MPF6661

2N6659,60,61
CASE 79-02, STYLE 6
TO-39 (TO-205AD)

MPF6659,60,61
CASE 29-03, STYLE 22
TO-226AE

TMOS
SWITCHING TRANSISTOR

N-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	2N6659 MPF6659	2N6660 MPF6660	2N6661 MPF6661	Unit
Drain-Source Voltage	V_{DS}	35	60	90	Vdc
Drain-Gate Voltage	V_{DG}	35	60	90	Vdc
Gate-Source Voltage	V_{GS}		± 30		Vdc
Drain Current — Continuous (1) Pulsed (2)	 I_D I_{DM}		 2.0 3.0		Adc

Rating	Symbol	2N6659 2N6660 2N6661	MPF6659 MPF6660 MPF6661	Unit
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	 6.25 50	 2.5 20	Watts mW/°C
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	 — —	 1.0 8.0	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

(1) The Power Dissipation of the package may result in a lower continuous drain current.
(2) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Zero-Gate-Voltage Drain Current (V_{DS} = Maximum Rating, V_{GS} = 0)		I_{DSS}	—	—	10	μAdc
Gate-Body Leakage Current (V_{GS} = 15 V, V_{DS} = 0)		I_{GSS}	—	—	100	nAdc
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 10 μA)	 2N6659, MPF6659 2N6660, MPF6660 2N6661, MPF6661	$V_{(BR)DSX}$	 35 60 90	 — — —	 — — —	Vdc
ON CHARACTERISTICS(1)						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)		$V_{GS(Th)}$	0.8	1.4	2.0	Vdc
Drain-Source On-Voltage (V_{GS} = 10 V, I_D = 1.0 A)	 2N6659, MPF6659 2N6660, MPF6660 2N6661, MPF6661	$V_{DS(on)}$	 — — —	 — — —	 1.8 3.0 4.0	Vdc
(V_{GS} = 5.0 V, I_D = 0.3 A)	2N6659, MPF6659 2N6660, MPF6660 2N6661, MPF6661		— — —	0.8 0.9 0.9	1.5 1.5 1.6	
Static Drain-Source On Resistance (V_{GS} = 10 Vdc, I_D = 1.0 Adc)	 2N6659, MPF6659 2N6660, MPF6660 2N6661, MPF6661	$r_{DS(on)}$	 — — —	 — — —	 1.8 3.0 4.0	Ohms
On-State Drain Current (V_{DS} = 25 V, V_{GS} = 10 V)		$I_{D(on)}$	1.0	2.0	—	Amps
SMALL-SIGNAL CHARACTERISTICS						
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	30	50	pF
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	3.6	10	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{oss}	—	20	40	pF
Forward Transconductance (V_{DS} = 25 V, I_D = 0.5 A)		g_{fs}	170	—	—	mmhos

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
SWITCHING CHARACTERISTICS(1)					
Rise Time	t_r	—	—	5.0	ns
Fall Time	t_f	—	—	5.0	ns
Turn-On Time	t_{on}	—	—	5.0	ns
Turn-Off Time	t_{off}	—	—	5.0	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

RESISTIVE SWITCHING

FIGURE 1 — SWITCHING TEST CIRCUIT

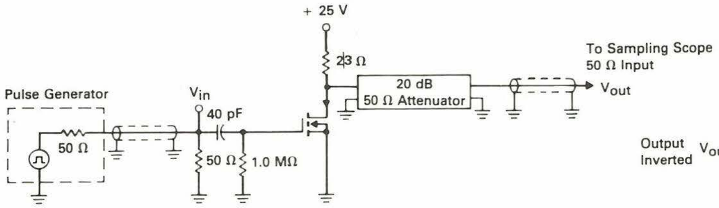


FIGURE 2 — SWITCHING WAVEFORMS

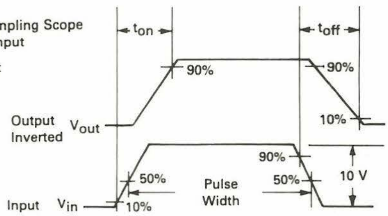


FIGURE 3 — $V_{GS(th)}$ NORMALIZED versus TEMPERATURE

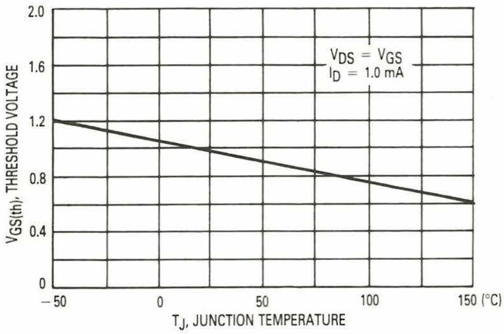


FIGURE 4 — ON-REGION CHARACTERISTICS

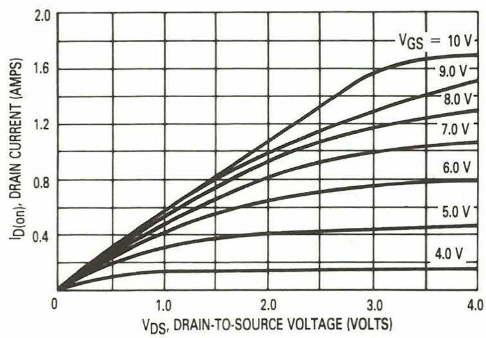


FIGURE 5 — OUTPUT CHARACTERISTICS

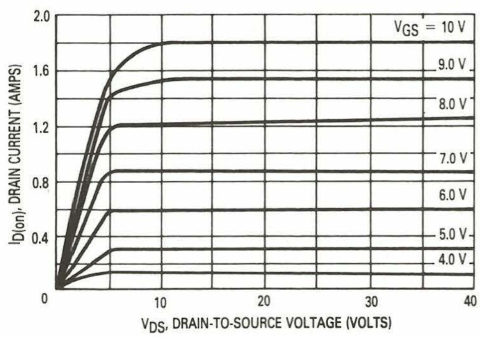
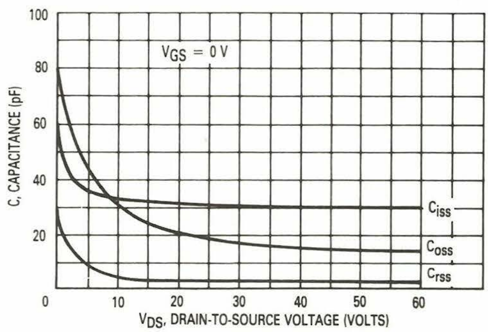
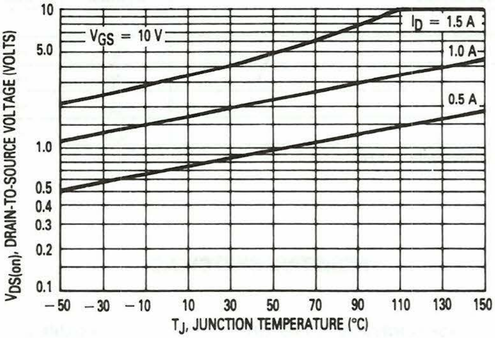


FIGURE 6 — CAPACITANCE versus DRAIN-TO-SOURCE VOLTAGE



6

FIGURE 7 — ON-VOLTAGE versus TEMPERATURE



6

3N128

CASE 20-03, STYLE 7
TO-72 (TO-206AF)

MOSFET AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	+20	Vdc
Drain-Gate Voltage	V_{DG}	+20	Vdc
Gate-Source Voltage	V_{GS}	±10	Vdc
Drain Current	I_D	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	330 2.2	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage(1) (I_G = −10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	−50	—	Vdc
Gate Reverse Current (V_{GS} = −8.0 Vdc, V_{DS} = 0) (V_{GS} = −8.0 Vdc, V_{DS} = 0, T_A = 125°C)	I_{GSS}	 — —	 0.05 5.0	nAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 50 μAdc)	$V_{GS(off)}$	−0.5	−8.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current(2) (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	5.0	25	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 1.0 kHz)	$\|Y_{fs}\|$	5000	12,000	μmhos
Input Admittance (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 200 MHz)	$Re(y_{is})$	—	800	μmhos
Output Conductance (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 200 MHz)	$Re(y_{os})$	—	500	μmhos
Forward Transconductance (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 200 MHz)	$Re(y_{fs})$	5000	—	μmhos
Input Capacitance (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 1.0 MHz)	C_{iss}	—	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 1.0 MHz)	C_{rss}	0.05	0.35	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 200 MHz)	NF	—	5.0	dB
Power Gain (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 200 MHz)	P_G	13.5	23	dB

(1) Caution Destructive Test, can damage gate oxide beyond operation.
(2) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

TYPICAL CHARACTERISTICS
($T_A = 25^{o}C$)

FIGURE 1 – DRAIN CHARACTERISTICS

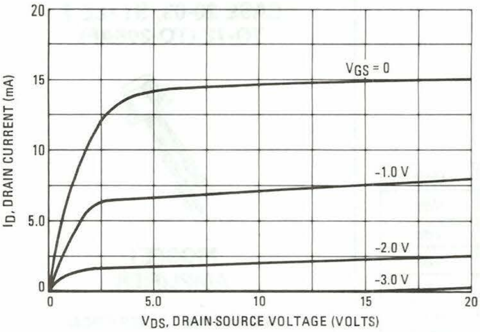
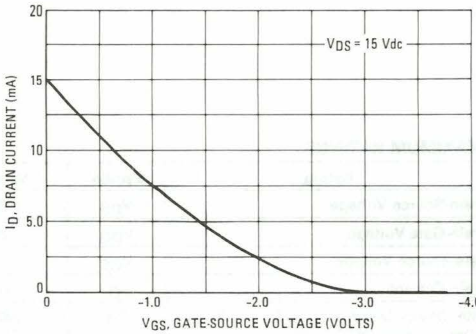


FIGURE 2 – TRANSFER CHARACTERISTICS



TYPICAL 1 kHz DRAIN CHARACTERISTICS
($T_A = 25^{o}C$, $V_{DS} = 15$ Vdc, f = 1.0 kHz)

6

FIGURE 3 – FORWARD TRANSADMITTANCE versus GATE BIAS VOLTAGE

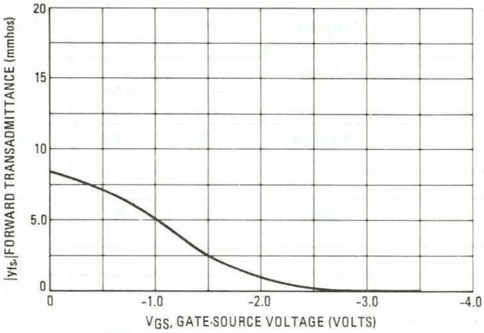
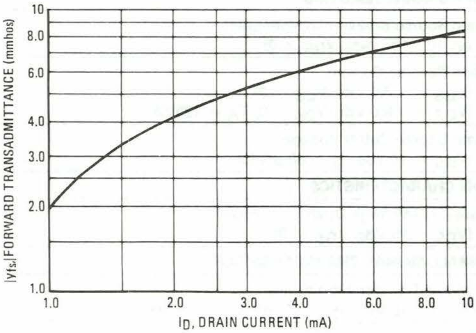


FIGURE 4 – FORWARD TRANSADMITTANCE versus DRAIN CURRENT



TYPICAL 200 MHz COMMON-SOURCE ADMITTANCE CHARACTERISTICS
($T_A = 25^{o}C$, $V_{DS} = 15$ Vdc, f = 200 MHz)

FIGURE 5 – INPUT ADMITTANCE (y_{is}) COMPONENTS

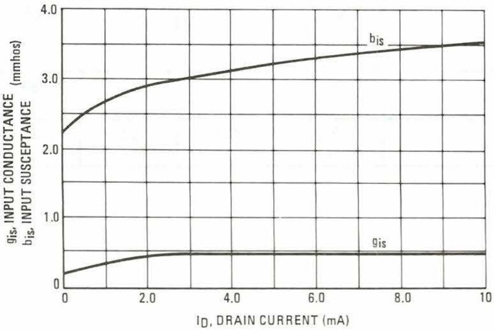


FIGURE 6 – FORWARD TRANSADMITTANCE (y_{fs}) COMPONENTS

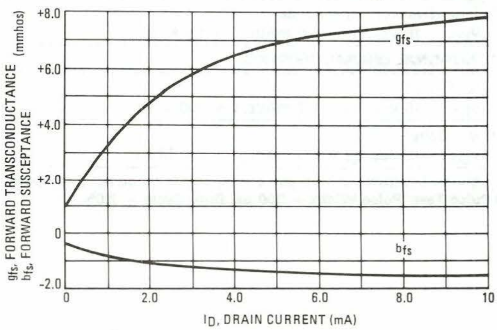


FIGURE 7 — REVERSE TRANSADMITTANCE (y_{rs}) COMPONENTS

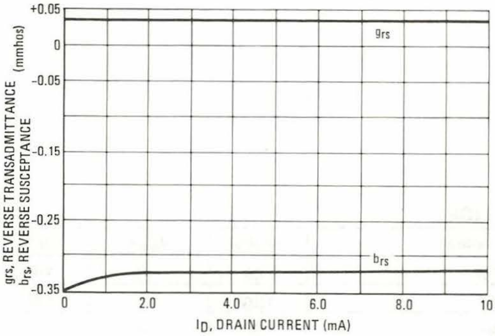


FIGURE 8 — OUTPUT ADMITTANCE (y_{os}) COMPONENTS

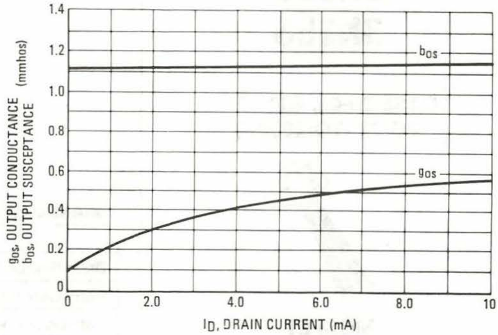


FIGURE 9 — POWER GAIN AND NOISE FIGURE versus DRAIN CURRENT

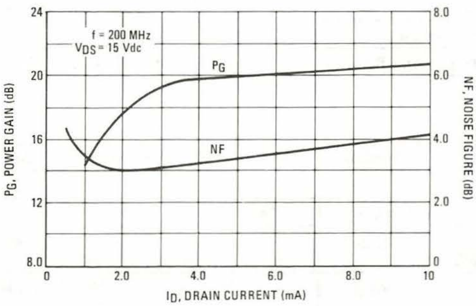


FIGURE 10 — POWER GAIN AND NOISE FIGURE versus DRAIN VOLTAGE

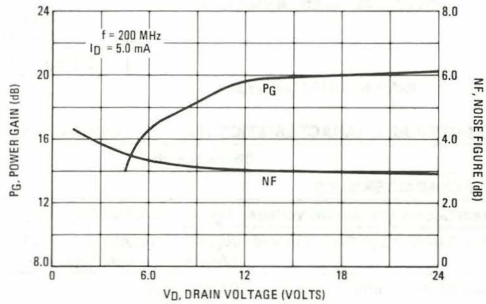


FIGURE 11 — THIRD ORDER INTERMODULATION DISTORTION

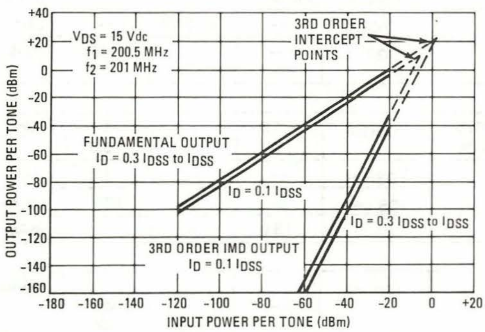
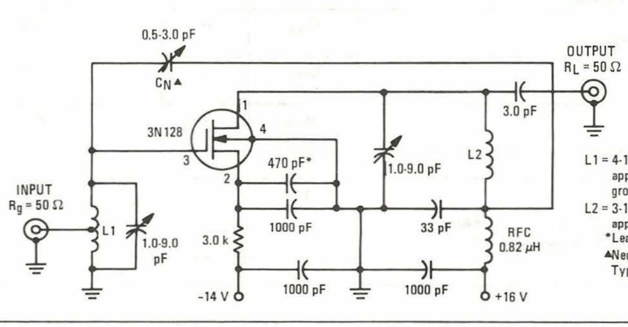


Figure 11 shows the typical third order intermodulation distortion (IMD) performance of the 3N128 at 200 MHz.

Both fundamental output and third order IMD output characteristics are plotted. The curves have been extrapolated to show the third order intermodulation output intercept point.

Performance for drain currents from I_{DSS} to 0.1 I_{DSS}, is given. The power gain and noise figure test amplifier shown in Figure 12 was used to generate the IMD data.

FIGURE 12 — POWER GAIN, NOISE FIGURE AND INTERMODULATION DISTORTION TEST CIRCUIT



L1 = 4-1/2 turns #20 AWG wire, 3/16" diameter, approximately 1/2" long, tapped 1 turn from ground end.
L2 = 3-1/2 turns #20 AWG wire, 3/8" diameter, approximately 1/2" long
*Leadless-type disc capacitor
▲Neutralization fixed for a Transistor having a Typical value of C_{rss} (0.13 pF)

3N155
3N156

CASE 20-03, STYLE 2
TO-72 (TO-206AF)

MOSFET SWITCHING

P-CHANNEL — ENHANCEMENT

Refer to 3N157 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	±35	Vdc
Drain-Gate Voltage	V_{DG}	±50	Vdc
Gate-Source Voltage	V_{GS}	±50	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Junction Temperature Range	T_J	−65 to +175	°C
Storage Channel Temperature Range	T_{stg}	−65 to +175	°C

6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (I_D = −10 μAdc, V_G = V_S = 0)	$V_{(BR)DSX}$	−35	—	—	Vdc
Zero-Gate-Voltage Drain Current (V_{DS} = −10 Vdc, V_{GS} = 0) (V_{DS} = −10 Vdc, V_{GS} = 0, T_A = 125°C)	I_{DSS}	— —	— —	−1.0 −1000	nAdc
Gate Reverse Current (V_{GS} = +50 Vdc, V_{DS} = 0) (V_{GS} = +25 Vdc, V_{DS} = 0)	I_{GSS}	— —	— —	+1000 +10	pAdc
Resistance Drain Source (I_D = 0, V_{GS} = 0)	$r_{DS(off)}$	$1 \times 10^{+10}$	—	—	Ohms
Resistance Gate Source Input (V_{GS} = −25 Vdc)	R_{GS}	—	$1 \times 10^{+16}$	—	Ohms
Gate Forward Leakage Current (V_{GS} = −50 Vdc, V_{DS} = 0) (V_{GS} = −25 Vdc, V_{DS} = 0)	$I_{G(f)}$	— —	— —	−1000 −10	pAdc
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = −10 Vdc, I_D = −10 μAdc) 3N155 3N156	$V_{GS(Th)}$	−1.5 −3.0	— —	−3.2 −5.0	Vdc
Drain-Source On-Voltage (I_D = −2.0 mAdc, V_{GS} = −10 Vdc)	$V_{DS(on)}$	—	—	−1.0	Vdc
Static Drain-Source On Resistance (I_D = 0 mAdc, V_{GS} = −10 Vdc)	$r_{DS(on)}$	—	—	600	Ohms
On-State Drain Current (V_{DS} = −15 Vdc, V_{GS} = −10 Vdc)	$I_{D(on)}$	−5.0	—	—	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source Resistance (V_{GS} = −10 Vdc, I_D = 0, f = 1.0 kHz) (V_{GS} = −15 Vdc, I_D = 0, f = 1.0 kHz)	$r_{ds(on)}$	 — —	 — —	 400 350	Ohms
Forward Transfer Admittance (V_{DS} = −15 Vdc, I_D = −2.0 mAdc, f = 1.0 kHz)	$\|y_{fs}\|$	1000	—	4000	μmhos
Input Capacitance (V_{DS} = −15 Vdc, V_{GS} = −10 Vdc, f = 140 kHz)	C_{iss}	—	—	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 0, f = 140 kHz)	C_{rss}	—	—	1.3	pF
Drain-Substrate Capacitance ($V_{D(SUB)}$ = −10 Vdc, f = 140 kHz)	$C_{d(sub)}$	—	—	4.0	pF

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Typ	Max	Unit
Turn-On Delay	(V_{DD} = −10 Vdc, $I_{D(on)}$ = −2.0 mAdc, $V_{GS(on)}$ = −10 Vdc, $V_{GS(off)}$ = 0)	t_d	—	—	45	μs
Rise Time		t_r	—	—	65	ns
Turn-Off Delay		t_s	—	—	60	ns
Fall Time		t_f	—	—	100	ns

3N157
3N158

CASE 20-03, STYLE 2
TO-72 (TO-206AF)

MOSFET
AMPLIFIER AND SWITCHING

P-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage*	V_{DS}	±35	Vdc
Drain-Gate Voltage*	V_{DG}	±50	Vdc
Gate-Source Voltage*	V_{GS}	±50	Vdc
Drain Current*	I_D	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C*	P_D	300 1.7	mW mW/°C
Junction Temperature Range*	T_J	−65 to +175	°C
Storage Channel Temperature Range*	T_{stg}	−65 to +175	°C

*JEDEC Registered Limits

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (I_D = −10 μAdc, V_G = V_S = 0)	$V_{(BR)DSX}$	−35	—	—	Vdc
Zero-Gate-Voltage Drain Current (V_{DS} = −15 Vdc, V_{GS} = 0) (V_{DS} = −35 Vdc, V_{GS} = 0)	I_{DSS}	— —	— —	−1.0 −10	nAdc μAdc
Gate Reverse Current* (V_{GS} = +25 Vdc, V_{DS} = 0) (V_{GS} = +50 Vdc, V_{DS} = 0)	I_{GSS}	— —	— —	+10 +10	pAdc nAdc
Input Resistance (V_{GS} = −25 Vdc)	R_{GS}	—	1 x 10^{+12}	—	Ohms
Gate Source Voltage* (V_{DS} = −15 Vdc, I_D = −0.5 mAdc) 3N157 3N158	V_{GS}	 −1.5 −3.0	 — —	 −5.5 −7.0	Vdc
Gate Forward Current* (V_{GS} = −25 Vdc, V_{DS} = 0) (V_{GS} = −50 Vdc, V_{DS} = 0) (V_{GS} = −25 Vdc, V_{DS} = 0, T_A = +55°C) (V_{GS} = −50 Vdc, V_{DS} = 0, T_A = +55°C)	$I_{G(f)}$	— — — —	— — — —	−10 −1.0 −10 −1.0	pAdc nAdc nAdc μAdc
ON CHARACTERISTICS					
Gate Threshold Voltage* (V_{DS} = −15 Vdc, I_D = −10 μAdc) 3N157 3N158	$V_{GS(Th)}$	 −1.5 −3.0	 — —	 −3.2 −5.0	Vdc
On-State Drain Current* (V_{DS} = −15 Vdc, V_{GS} = −10 Vdc)	$I_{D(on)}$	−5.0	—	—	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance* (V_{DS} = −15 Vdc, I_D = −2.0 mAdc, f = 1.0 kHz)	$\lvert y_{fs} \rvert$	1000	—	4000	μmhos
Output Admittance* (V_{DS} = −15 Vdc, I_D = −2.0 mAdc, f = 1.0 kHz)	$\lvert y_{os} \rvert$	—	—	60	μmhos
Input Capacitance* (V_{DS} = −15 Vdc, V_{GS} = 0, f = 140 kHz)	C_{iss}	—	—	5.0	pF
Reverse Transfer Capacitance* (V_{DS} = −15 Vdc, V_{GS} = 0, f = 140 kHz)	C_{rss}	—	—	1.3	pF
Drain-Substrate Capacitance ($V_{D(SUB)}$ = −10 Vdc, f = 140 kHz)	$C_{d(sub)}$	—	—	4.0	pF
Noise Voltage (R_S = 0, BW = 1.0 Hz, V_{DS} = −15 Vdc, I_D = −2.0 mAdc, f = 100 Hz) (R_S = 0, BW = 1.0 Hz, V_{DS} = −15 Vdc, I_D = −2.0 mAdc, f = 1.0 kHz)	e_n	 — —	 300 120	 — 500	NV/$\sqrt{Hz}$

*JEDEC Registered Limits

FIGURE 1 – FORWARD TRANSCONDUCTANCE

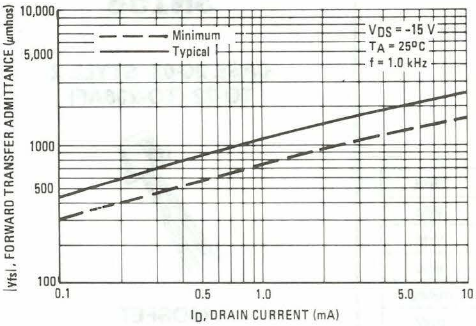


FIGURE 2 – OUTPUT TRANSCONDUCTANCE

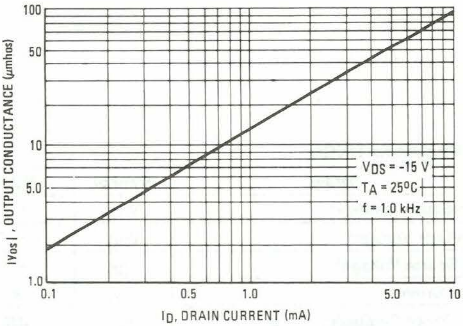


FIGURE 3 – FORWARD TRANSCONDUCTANCE versus TEMPERATURE

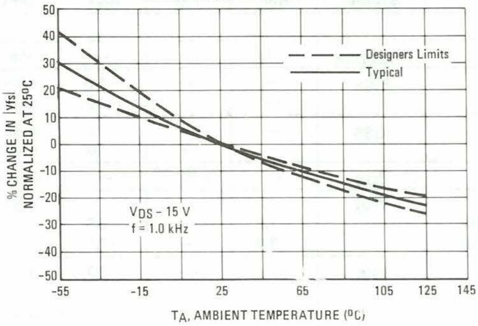


FIGURE 4 – BIAS CURVE

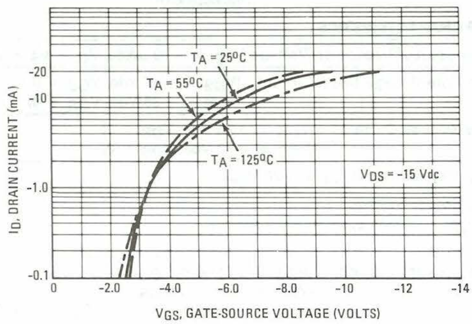


FIGURE 5 – "ON" DRAIN-SOURCE VOLTAGE

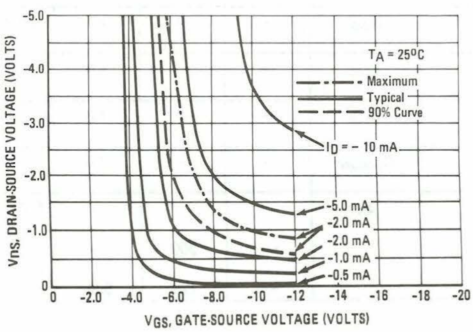
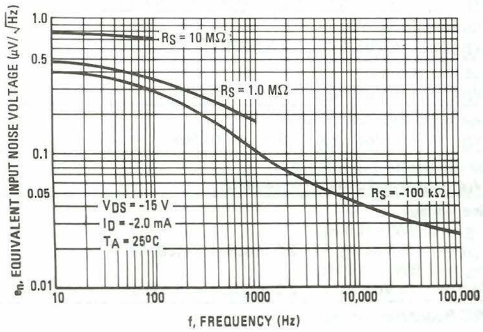


FIGURE 6 – EQUIVALENT INPUT NOISE VOLTAGE



SWITCHING CHARACTERISTICS

(T_A = 25°C)

FIGURE 7 – TURN-ON DELAY TIME

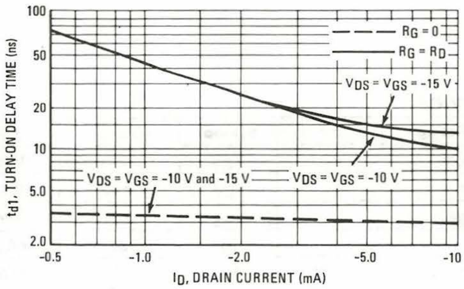


FIGURE 8 – RISE TIME

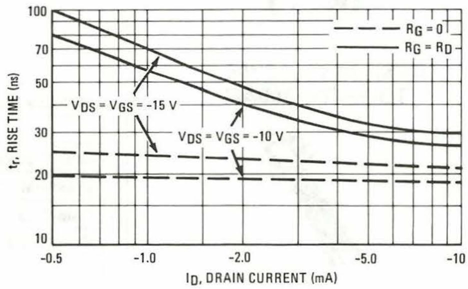


FIGURE 9 – TURN-OFF DELAY TIME

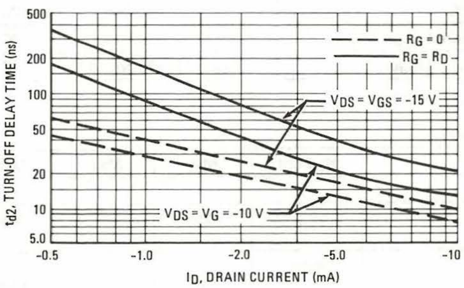


FIGURE 10 – FALL TIME

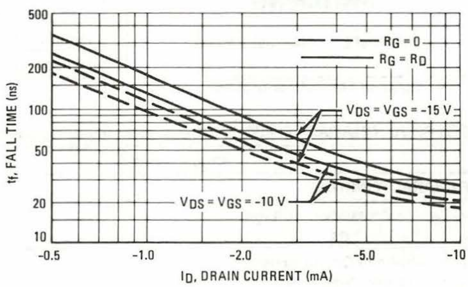


FIGURE 11 – SWITCHING CIRCUIT and WAVEFORMS

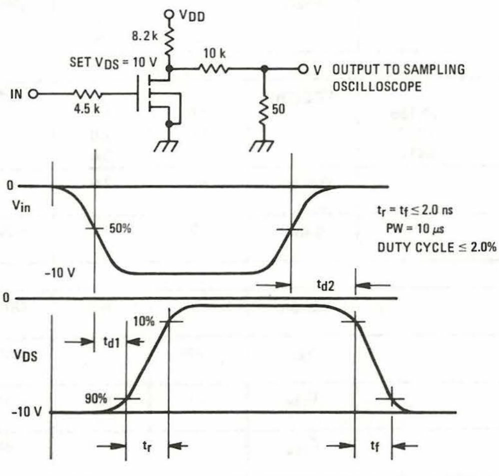
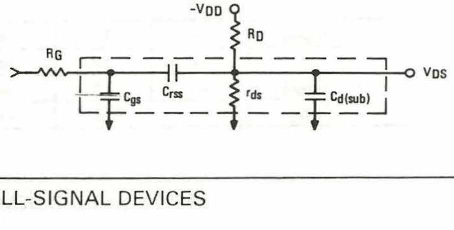


FIGURE 12 – SWITCHING CIRCUIT with MOSFET EQUIVALENT MODEL



The switching characteristics shown above were measured in a test circuit similar to Figure 11. At the beginning of the switching interval, the gate voltage is at ground and the gate source capacitance (C_{gs} • C_{rss} • C_{rss}) has no charge. The drain voltage is at V_{DD} and thus the feedback capacitance (C_{rss}) is charged to V_{DD}. Similarly, the drain substrate capacitance ($C_{d(sub)}$) is charged to V_{DD} since the substrate and source are connected to ground.

During the turn-on interval C_{gs} is charged to V_{GS} (the input voltage) through R_G (generator impedance) (Figure 12). C_{rss} must be discharged to V_{GS} • $V_{D(on)}$ through R_G and the parallel combination of the load resistor (R_D) and the channel resistance (r_{ds}). In addition, $C_{d(sub)}$ is discharged to a low value ($V_{D(on)}$) through R_D in parallel with r_{ds}. During turn-off this charge flow is reversed.

Predicting turn-on time proves to be somewhat difficult since the channel resistance (r_{ds}) is a function of the gate source voltage (V_{GS}). As C_{gs} becomes charged V_{GS} is approaching V_{in} and r_{ds} decreases (see Figure 5) and since C_{rss} and $C_{d(sub)}$ are charged through r_{ds}, turn-on time is quite non-linear.

If the charging time of C_{gs} is short compared to that of C_{rss} and $C_{d(sub)}$, then r_{ds} (which is in parallel with R_D) will be low compared to R_D during the switching interval and will largely determine the turn-on time. On the other hand, during turn-off r_{ds} will be almost an open circuit requiring C_{rss} and $C_{d(sub)}$ to be charged through R_D and resulting in a turn-off time that is long compared to the turn-on time. This is especially noticeable for the curves where R_G • 0 and C_{gs} is charged through the pulse generator impedance only.

The switching curves shown with R_G • R_D simulate the switching behavior of cascaded stages where the driving source impedance is normally the same as the load impedance. The set of curves with R_G • 0 simulates a low source impedance drive such as might occur in complementary logic circuits.

6

3N169
3N170
3N171

CASE 20-03, STYLE 2
TO-72 (TO-206AF)

MOSFET SWITCHING

N-CHANNEL — ENHANCEMENT

Refer to 2N4351 for graphs.

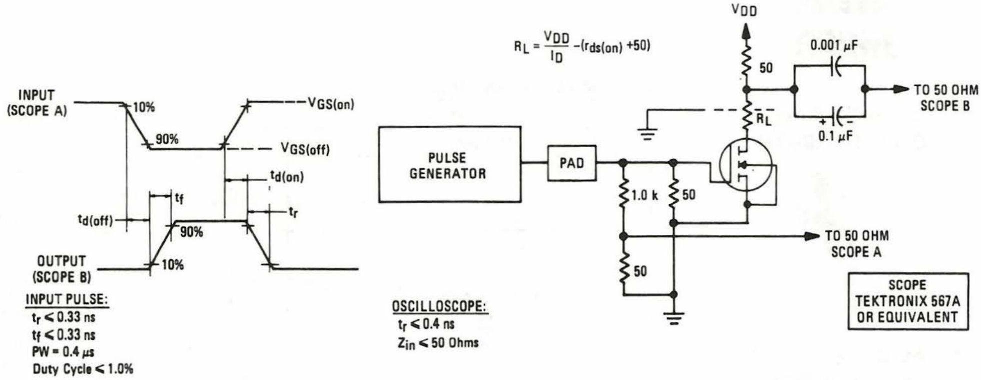
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	±35	Vdc
Gate-Source Voltage	V_{GS}	±35	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.7	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	800 4.56	mW mW/°C
Junction Temperature Range	T_J	175	°C
Storage Temperature Range	T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage (I_D = 10 μAdc, V_{GS} = 0)	$V_{(BR)DSX}$	25	—	Vdc
Zero-Gate-Voltage Drain Current (V_{DS} = 10 Vdc, V_{GS} = 0) (V_{DS} = 10 Vdc, V_{GS} = 0, T_A = 125°C)	I_{DSS}	 — —	 10 1.0	 nAdc μAdc
Gate Reverse Current (V_{GS} = −35 Vdc, V_{DS} = 0) (V_{GS} = −35 Vdc, V_{DS} = 0, T_A = 125°C)	I_{GSS}	 — —	 10 100	pAdc
ON CHARACTERISTICS				
Gate Threshold Voltage (V_{DS} = 10 Vdc, I_D = 10 μAdc) 3N169 3N170 3N171	$V_{GS(Th)}$	 0.5 1.0 1.5	 1.5 2.0 3.0	Vdc
Drain-Source On-Voltage (I_D = 10 mAdc, V_{GS} = 10 Vdc)	$V_{DS(on)}$	—	2.0	Vdc
On-State Drain Current (V_{GS} = 10 Vdc, V_{DS} = 10 Vdc)	$I_{D(on)}$	10	—	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Drain-Source Resistance (V_{GS} = 10 Vdc, I_D = 0, f = 1.0 kHz)	$r_{ds(on)}$	—	200	Ohms
Forward Transfer Admittance (V_{DS} = 10 Vdc, I_D = 2.0 mAdc, f = 1.0 kHz)	$\|y_{fs}\|$	1000	—	μmhos
Input Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	1.3	pF
Drain-Substrate Capacitance ($V_{D(SUB)}$ = 10 Vdc, f = 1.0 MHz)	$C_{d(sub)}$	—	5.0	pF
SWITCHING CHARACTERISTICS				
Turn-On Delay Time (V_{DD} = 10 Vdc, $I_{D(on)}$ = 10 mAdc, $V_{GS(on)}$ = 10 Vdc, $V_{GS(off)}$ = 0, R_G' = 50 Ohms) See Figure 1	$t_{d(on)}$	—	3.0	ns
Rise Time	t_r	—	10	ns
Turn-Off Delay Time	$t_{d(off)}$	—	3.0	ns
Fall Time	t_f	—	15	ns

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



6

3N201
3N202
3N203

CASE 20-03, STYLE 9
TO-72 (TO-206AF)

DUAL-GATE MOSFET
VHF AMPLIFIER

N-CHANNEL — DEPLETION

Refer to MPF201 for additional graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG1} V_{DG2}	30 30	Vdc
Drain Current	I_D	50	mAdc
Gate Current	I_{G1} I_{G2}	±10 ±10	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	360 2.4	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.2 8.0	Watt mW/°C
Lead Temperature	T_L	300	°C
Junction Temperature Range	T_J	−65 to +175	°C
Storage Channel Temperature Range	T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

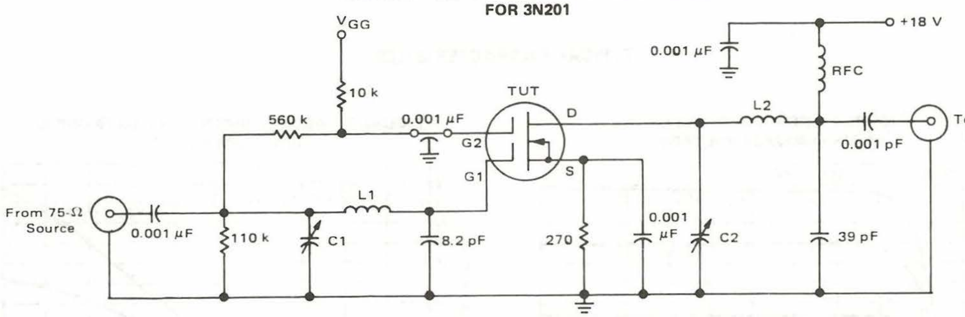
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage ($I_D = 10\ \mu Adc$, $V_S = 0$, $V_{G1S} = V_{G2S} = -5.0$ Vdc)	$V_{(BR)DSX}$	25	—	—	Vdc
Gate 1-Source Breakdown Voltage(1) ($I_{G1} = \pm 10$ mAdc, $V_{G2S} = V_{DS} = 0$)	$V_{(BR)G1SO}$	±6.0	±12	±30	Vdc
Gate 2-Source Breakdown Voltage(1) ($I_{G2} = \pm 10$ mAdc, $V_{G1S} = V_{DS} = 0$)	$V_{(BR)G2SO}$	±6.0	±12	±30	Vdc
Gate 1 Leakage Current ($V_{G1S} = \pm 5.0$ Vdc, $V_{G2S} = V_{DS} = 0$) ($V_{G1S} = -5.0$ Vdc, $V_{G2S} = V_{DS} = 0$, $T_A = 150°C$)	I_{G1SS}	 — —	 ±.040 —	 ±10 −10	 nAdc μAdc
Gate 2 Leakage Current ($V_{G2S} = \pm 5.0$ Vdc, $V_{G1S} = V_{DS} = 0$) ($V_{G2S} = -5.0$ Vdc, $V_{G1S} = V_{DS} = 0$, $T_A = 150°C$)	I_{G2SS}	 — —	 ±.050 —	 ±10 −10	 nAdc μAdc
Gate 1 to Source Cutoff Voltage ($V_{DS} = 15$ Vdc, $V_{G2S} = 4.0$ Vdc, $I_D = 20\ \mu Adc$)	$V_{G1S(off)}$	−0.5	−1.5	−5.0	Vdc
Gate 2 to Source Cutoff Voltage ($V_{DS} = 15$ Vdc, $V_{G1S} = 0$, $I_D = 20\ \mu Adc$)	$V_{G2S(off)}$	−0.2	−1.4	−5.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(2) ($V_{DS} = 15$ Vdc, $V_{G1S} = 0$, $V_{G2S} = 4.0$ Vdc) 3N201,3N202 3N203	I_{DSS}	 6.0 3.0	 13 11	 30 15	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance(3) ($V_{DS} = 15$ Vdc, $V_{G2S} = 4.0$ Vdc, $V_{G1S} = 0$, f = 1.0 kHz) 3N201,3N202 3N203	$\|Y_{fs}\|$	 8.0 7.0	 12.8 12.5	 20 15	mmhos
Input Capacitance ($V_{DS} = 15$ Vdc, $V_{G2S} = 4.0$ Vdc, $I_D = I_{DSS}$, f = 1.0 MHz)	C_{iss}	—	3.3	—	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ Vdc, $V_{G2S} = 4.0$ Vdc, $I_D = 10$ mAdc, f = 1.0 MHz)	C_{rss}	0.005	0.014	0.03	pF
Output Capacitance ($V_{DS} = 15$ Vdc, $V_{G2S} = 4.0$ Vdc, $I_D = I_{DSS}$, f = 1.0 MHz)	C_{oss}	—	1.7	—	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure ($V_{DD} = 18$ Vdc, $V_{GG} = 7.0$ Vdc, f = 200 MHz) (Figure 1) 3N201 ($V_{DD} = 18$ Vdc, $V_{GG} = 6.0$ Vdc, f = 45 MHz) (Figure 3) 3N203	NF	 — —	 1.8 5.3	 4.5 6.0	dB

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Common Source Power Gain		G_{ps}				dB
(V_{DD} = 18 Vdc, V_{GG} = 7.0 Vdc, f = 200 MHz) (Figure 1)	3N201		15	20	25	
(V_{DD} = 18 Vdc, V_{GG} = 6.0 Vdc, f = 45 MHz) (Figure 3)	3N203		20	25	30	
(V_{DD} = 18 Vdc, f_{LO} = 245 MHz, f_{RF} = 200 MHz) (Figure 2)	3N202	G_c(5)	15	19	25	
Bandwidth		BW				MHz
(V_{DD} = 18 Vdc, V_{GG} = 7.0 Vdc, f = 200 MHz) (Figure 1)	3N201		5.0	—	9.0	
(V_{DD} = 18 Vdc, f_{LO} = 245 MHz, f_{RF} = 200 MHz) (Figure 2)	3N202		4.5	—	7.5	
(V_{DD} = 18 Vdc, V_{GG} = 6.0 Vdc, f = 45 MHz) (Figure 3)	3N203		3.0	—	6.0	
Gain Control Gate-Supply Voltage(4)		$V_{GG(GC)}$				Vdc
(V_{DD} = 18 Vdc, ΔG_{ps} = −30 dB, f = 200 MHz) (Figure 1)	3N201		0	−1.0	−3.0	
(V_{DD} = 18 Vdc, ΔG_{ps} = −30 dB, f = 45 MHz) (Figure 3)	3N203		0	−0.6	−3.0	

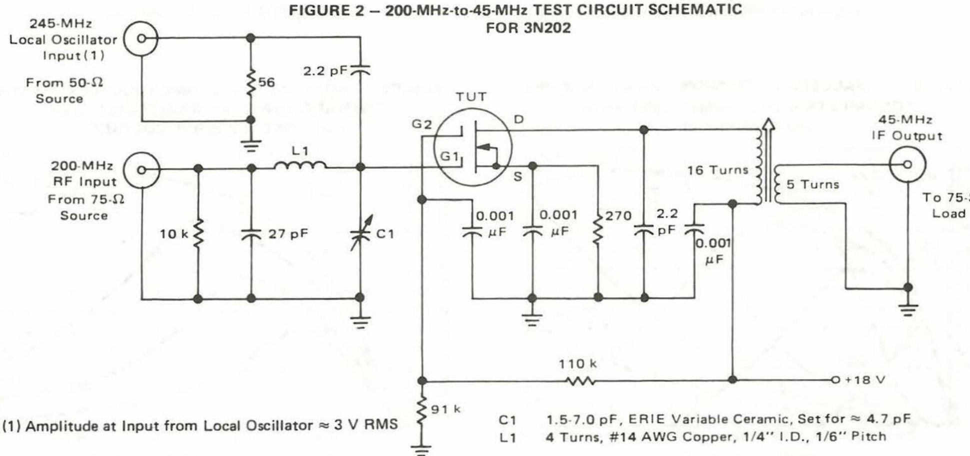
(1) All gate breakdown voltages are measured while the device is conducting rated gate current. This ensures that the gate-voltage limiting network is functioning properly.
(2) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.
(3) This parameter must be measured with bias voltages applied for less than 5 seconds to avoid overheating.
(4) ΔG_{ps} is defined as the change in G_{ps} from the value at V_{GG} = 7.0 volts (3N201) and V_{GG} = 6.0 volts (3N203).
(5) Power Gain Conversion

FIGURE 1 — 200-MHz TEST CIRCUIT SCHEMATIC FOR 3N201



C1 4.0-30 pF, ERIE Variable Ceramic, Set for ≈ 22 pF
C2 4.0-30 pF, ERIE Variable Ceramic, Set for ≈ 10 pF
L1 4 Turns, #14 AWG Cooper, 1/4" I.D., 1/6" Pitch
L2 3 Turns, #14 AWG Cooper, 1/4" I.D., 1/8" Pitch
RFC DELEVAN No. 153712, 1.0 μH

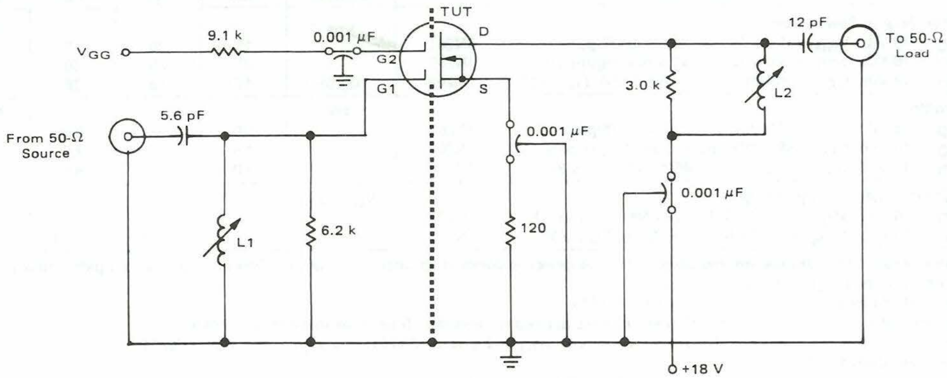
FIGURE 2 — 200-MHz-to-45-MHz TEST CIRCUIT SCHEMATIC FOR 3N202



(1) Amplitude at Input from Local Oscillator ≈ 3 V RMS

C1 1.5-7.0 pF, ERIE Variable Ceramic, Set for ≈ 4.7 pF
L1 4 Turns, #14 AWG Copper, 1/4" I.D., 1/6" Pitch

FIGURE 3 — 45-MHz TEST CIRCUIT SCHEMATIC
3N203



L1 14 Turns, #30 AWG Copper, Close-Wound 7/32" OD form with ARNOLD ENGINEERING "J" Tuning Core

L2 10 Turns, #30 AWG Copper, Close-Wound 7/32" OD form with ARNOLD ENGINEERING "J" Tuning Core

6

TYPICAL CHARACTERISTICS

FIGURE 4 — DRAIN CURRENT versus DRAIN to SOURCE VOLTAGE

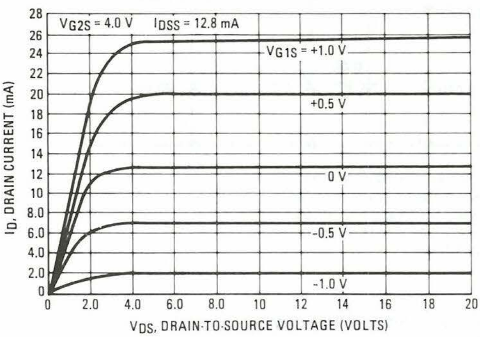


FIGURE 5 — DRAIN CURRENT versus GATE-ONE to SOURCE VOLTAGE

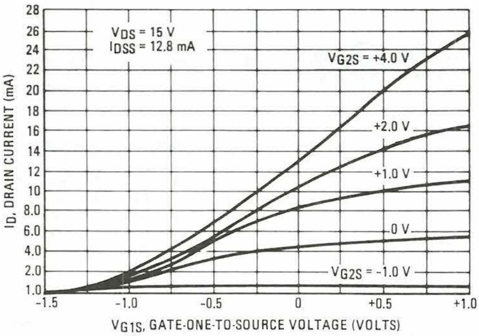


FIGURE 6 — SMALL-SIGNAL COMMON-SOURCE GATE-ONE FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

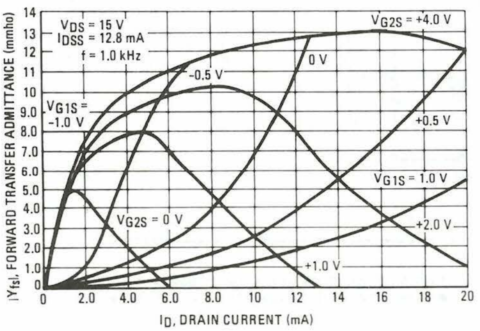


FIGURE 7 — SMALL-SIGNAL COMMON-SOURCE GATE-ONE FORWARD TRANSFER ADMITTANCE versus GATE-ONE to SOURCE VOLTAGE

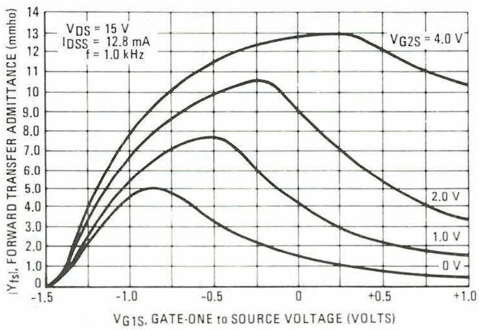


FIGURE 8 — SMALL-SIGNAL COMMON-SOURCE GATE-ONE FORWARD TRANSFER ADMITTANCE versus GATE-TWO to SOURCE VOLTAGE

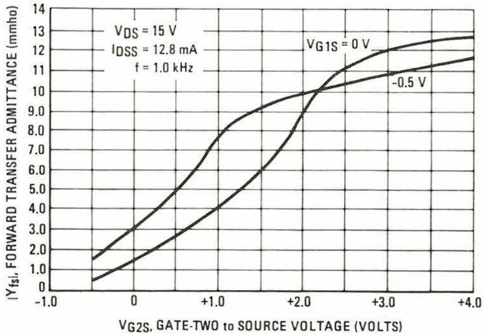
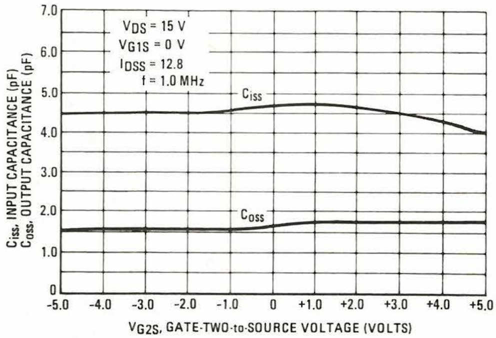


FIGURE 9 — SMALL-SIGNAL COMMON-SOURCE GATE-ONE INPUT AND OUTPUT CAPACITANCE versus GATE-TWO-to-SOURCE VOLTAGE



TYPICAL CHARACTERISTICS

FIGURE 10 — COMMON-SOURCE POWER GAIN AND SPOT NOISE FIGURE versus DRAIN CURRENT

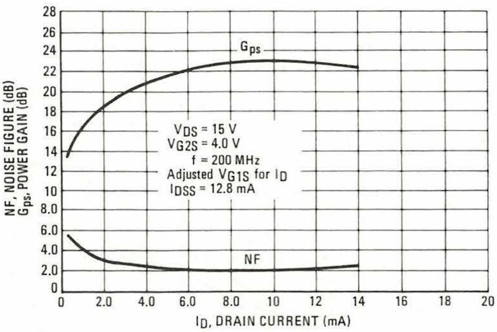
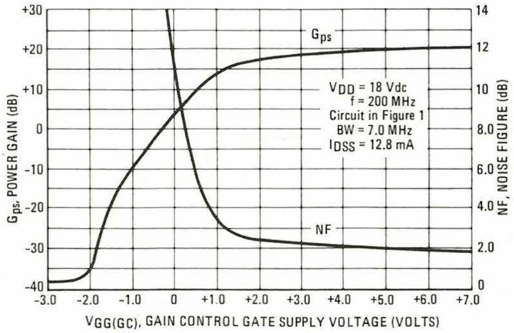


FIGURE 11 — COMMON-SOURCE POWER GAIN AND SPOT NOISE FIGURE versus GAIN CONTROL GATE-SUPPLY VOLTAGE — 3N201



6

FIGURE 12 — COMMON-SOURCE POWER GAIN versus DRAIN SUPPLY CURRENT — 3N201

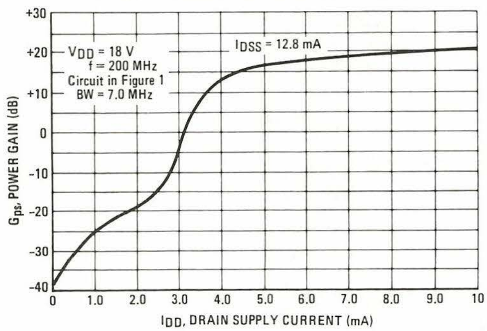


FIGURE 13 — SMALL-SIGNAL COMMON-SOURCE CONVERSION POWER GAIN versus LOCAL OSCILLATOR INPUT VOLTAGE — 3N202

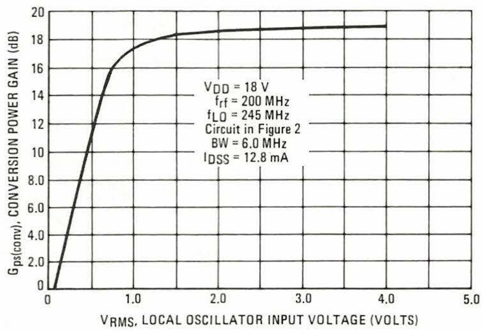
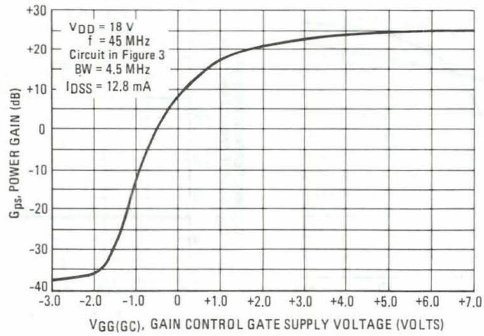


FIGURE 14 – SMALL-SIGNAL COMMON SOURCE INSERTION POWER GAIN versus GAIN CONTROL GATE-SUPPLY VOLTAGE – 3N203



TYPICAL CHARACTERISTICS

FIGURE 15 – SMALL-SIGNAL GATE ONE FORWARD TRANSFER ADMITTANCE versus FREQUENCY

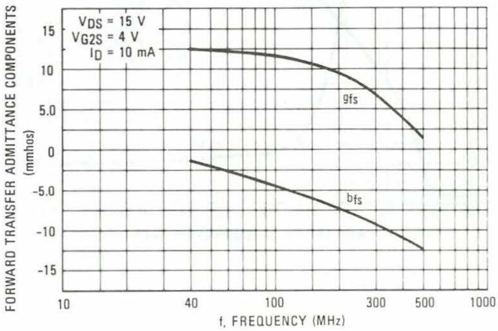


FIGURE 16 – SMALL-SIGNAL GATE ONE INPUT ADMITTANCE versus FREQUENCY

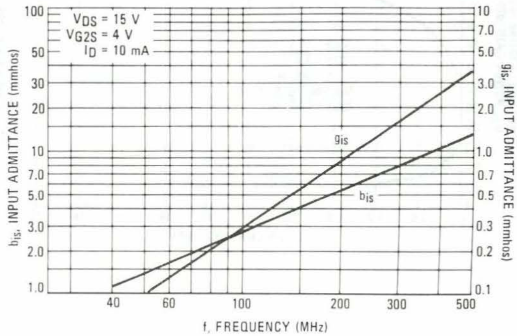
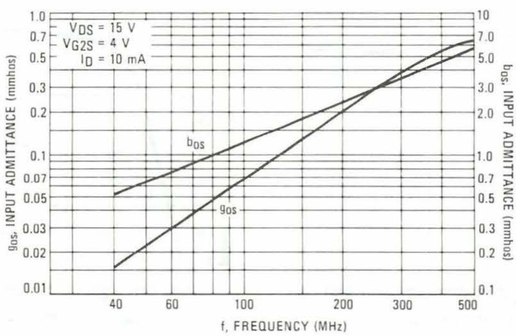


FIGURE 17 – SMALL-SIGNAL GATE ONE OUTPUT ADMITTANCE versus FREQUENCY



3N204
3N205

CASE 20-03, STYLE 9
TO-72 (TO-206AF)

DUAL GATE
MOS-FET

N-CHANNEL — DEPLETION

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Drain Current	I_D	50	mA
Reverse Gate Current	I_G	−10	mA
Forward Gate Current	I_{GF}	10	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.4	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 0.8	mW mW/°C
Lead Temperature	T_L	300	°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65°C to +175°C	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage (I_D = 10 μA, V_{G1} = V_{G2} = −5.0 V)	$V_{(BR)DSX}$	25	—	Vdc
Gate 1-Source Breakdown Voltage (I_{G1} = ±10 mA) Note 1	$V_{(BR)G1SO}$	±6	±30	Vdc
Gate 2-Source Breakdown Voltage (I_{G2} = ±10 mA) Note 1	$V_{(BR)G2SO}$	±6	±30	Vdc
Gate 1 Leakage Current (V_{G1S} = ±5.0 V, V_{G2S} = V_{DS} = 0)	I_{G1SS}	—	±10	nA
Gate 2 Leakage Current (V_{G2S} = ±5.0 V, V_{G1S} = V_{DS} = 0)	I_{G2SS}	—	±10	nA
Gate 1 to Source Cutoff Voltage (V_{DS} = 15 V, V_{G2S} = 4.0 V, I_D = 20 μA)	$V_{G1S(off)}$	−0.5	−4.0	Vdc
Gate 2 to Source Cutoff Voltage (V_{DS} = 15 V, V_{G1S} = 0 V, I_D = 20 μA)	$V_{G2S(off)}$	−0.2	−4.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current* (V_{DS} = 15 V, V_{G2S} = 4.0 V, V_{G1S} = 0 V)	I_{DSS}*	6	30	mA
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 15 V, V_{G2S} = 4.0 V, V_{G1S} = 0 V, f = 1.0 kHz) Note 2	$\lvert Y_{fs} \rvert$	10	22	mmhos
Input Capacitance (V_{DS} = 15 V, V_{G2S} = 4.0 V, I_D = I_{DSS}, f = 1.0 Mhz)	C_{iss}	Typ. 3.0		pF
Reverse Transfer Capacitance (V_{DS} = 15 V, V_{G2S} = 4.0 V, I_D = 10 mA, f = 1.0 MHz)	C_{rss}	0.005	0.03	pF
Output Capacitance (V_{DS} = 15 V, V_{G2S} = 4.0 V, I_D = I_{DSS}, f = 1.0 MHz)	C_{oss}	Typ. 1.4		pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure (V_{DD} = 18 V, V_{GG} = 7.0 V, f = 200 MHz) 3N204 (V_{DS} = 15 V, V_{G2S} = 4.0 V, I_D = 10 mA, f = 450 MHz) 3N204	NF	 — —	 3.5 5.0	dB
Common Source Power Gain (V_{DD} = 18 V, V_{GG} = 7.0 V, f = 200 MHz) 3N204 (V_{DS} = 15 V, V_{G2S} = 4.0 V, I_D = 10 mA, f = 450 MHz) 3N204	G_{ps}	 20 14	 28 —	dB

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Bandwidth (V_{DD} = 18 V, V_{GG} = 7.0 V, f = 200 MHz) (V_{DD} = 18 V, f_{LO} = 245 MHz, f_{RF} = 200 MHz) (Note 4)	 3N3204 3N205	BW	 7.0 4.0	 12 7.0	MHz
Gain Control Gate-Supply Voltage (Note 3) (V_{DD} = 18 V, ΔGPS = 300 dB, f = 200 MHz)	 3N204	$V_{GG(GC)}$	0	−2.0	Vdc
Conversion Gain (Note 4) (V_{DD} = 18 V, f_{LO} = 245 MHz, f_{RF} = 200 MHz)	 3N205	$G_{(conv.)}$	17	28	dB

*PW = 30 μsec, Duty Cycle ≤ 2.0%.

(1) All gate breakdown voltages are measured while the device is conducting rated gate current. This insures that the gate voltage limiting network is functioning propertly.

(2) This parameter must be measured with bias voltages applied for less than five (5) seconds to avoid overheating.

(3) ΔG_{ps} is defined as the change in G_{ps} from the value at V_{GG} = 7.0 V.

(4) Amplitude at input from local oscillator is 3 volts RMS.

6

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Drain-Source Voltage	V_{DS}	25		Vdc
Drain-Gate Voltage	V_{DG1} V_{DG2}	30 30		Vdc
Drain Current	I_D	30		mAdc
Gate Current	I_{G1R} I_{G1F} I_{G2R} I_{G2F}	−10 10 −10 10		mAdc
		3N209	MPF209	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 1.71	— —	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D		300 2.4	mW mW/°C
Lead Temperature, 1/16″ From Seated Surface for 10 seconds	T_L	260	200	°C
Storage Channel Temperature Range	T_{stg}	−65 to +175	−65 to +150	°C
Operating Channel Temperature	$T_{channel}$	175	150	°C

3N209
MPF209

3N209
CASE 20-03, STYLE 9
TO-72 (TO-206AF)

MPF209
CASE 317-01, STYLE 1

DUAL-GATE
MOSFET
UHF COMMUNICATIONS

N-CHANNEL — DEPLETION

6

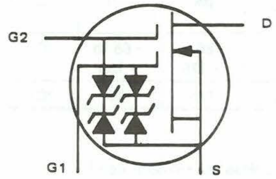
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage ($I_D = 10\ \mu Adc$, $V_{G1S} = -4.0$ Vdc, $V_{G2S} = 4.0$ Vdc)	$V_{(BR)DSX}$	25	—	—	Vdc
Gate 1 — Source Forward Breakdown Voltage ($I_{G1} = 10$ mAdc, $V_{G2S} = V_{DS} = 0$)	$V_{(BR)G1SSF}$	7.0	—	22	Vdc
Gate 1 — Source Reverse Breakdown Voltage ($I_{G1} = -10$ mAdc, $V_{G2S} = V_{DS} = 0$)	$V_{(BR)G1SSR}$	−7.0	—	−22	Vdc
Gate 2 — Source Forward Breakdown Voltage ($I_{G2} = 10$ mAdc, $V_{G1S} = V_{DS} = 0$)	$V_{(BR)G2SSF}$	7.0	—	22	Vdc
Gate 2 — Source Reverse Breakdown Voltage ($I_{G2} = -10$ mAdc, $V_{G1S} = V_{DS} = 0$)	$V_{(BR)G2SSR}$	−7.0	—	−22	Vdc
Gate 1 — Terminal Forward Current ($V_{G1S} = 6.0$ Vdc, $V_{G2S} = V_{DS} = 0$)	I_{G1SSF}	—	—	20	nAdc
Gate 1 — Terminal Reverse Current ($V_{G1S} = -6.0$ Vdc, $V_{G2S} = V_{DS} = 0$) ($V_{G1S} = -6.0$ Vdc, $V_{G2S} = V_{DS} = 0$, $T_A = 150°C$)	I_{G1SSR}	— —	— —	−20 −10	nAdc μAdc
Gate 2 — Terminal Forward Current ($V_{G2S} = 6.0$ Vdc, $V_{G1S} = V_{DS} = 0$)	I_{G2SSF}	—	—	20	nAdc
Gate 2 — Terminal Reverse Current ($V_{G2S} = -6.0$ Vdc, $V_{G1S} = V_{DS} = 0$) ($V_{G2S} = -6.0$ Vdc, $V_{G1S} = V_{DS} = 0$, $T_A = 150°C$)	I_{G2SSR}	— —	— —	−20 −10	nAdc μAdc
ON CHARACTERISTICS					
Gate 1 — Zero Voltage Drain Current ($V_{DS} = 15$ Vdc, $V_{G1S} = 0$, $V_{G2S} = 4.0$ Vdc)	I_{DSS}	5.0	—	30	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance ($V_{DS} = 15$ Vdc, $V_{G2S} = 4.0$ Vdc, $I_D = 10$ mAdc, f = 1.0 kHz)	y_{fs}	10	13	20	mmhos
Input Capacitance ($V_{DS} = 15$ Vdc, $V_{G2S} = 4.0$ Vdc, $I_D \geq 5.0$ mAdc, f = 1.0 MHz)	C_{iss}	—	3.3	7.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ Vdc, $V_{G2S} = 4.0$ Vdc, $I_D \geq 5.0$ mAdc, f = 1.0 MHz)	C_{rss}	0.005	0.023	0.03	pF
Output Capacitance ($V_{DS} = 15$ Vdc, $V_{G2S} = 4.0$ Vdc, $I_D \geq 5.0$ mAdc, f = 1.0 MHz)	C_{oss}	0.5	2.0	4.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, f = 500 MHz)	NF	—	4.0	6.0	dB
Common Source Power Gain (Figure 12) (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, f = 500 MHz)	G_{ps}	10	13	20	dB
*Bandwidth (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, f = 500 MHz)	BW	7.0	—	17	MHz

FIGURE 1 – MOS FET CIRCUIT SCHEMATIC



6

TYPICAL SCATTERING PARAMETERS

FIGURE 2 – S_{11}, INPUT REFLECTION COEFFICIENT versus FREQUENCY

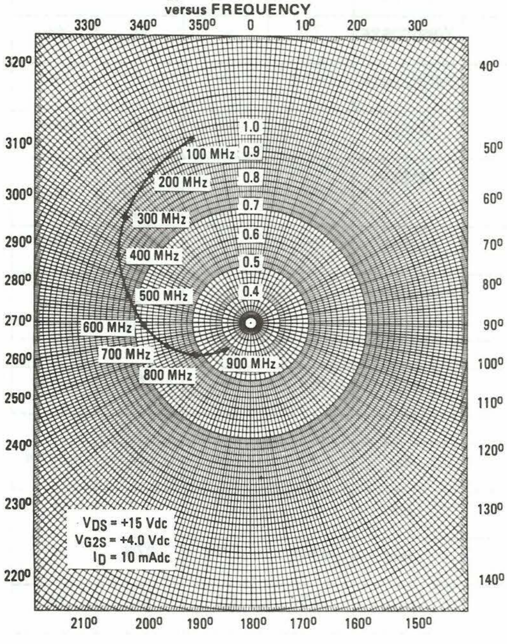


FIGURE 3 – S_{12}, REVERSE TRANSMISSION COEFFICIENT versus FREQUENCY

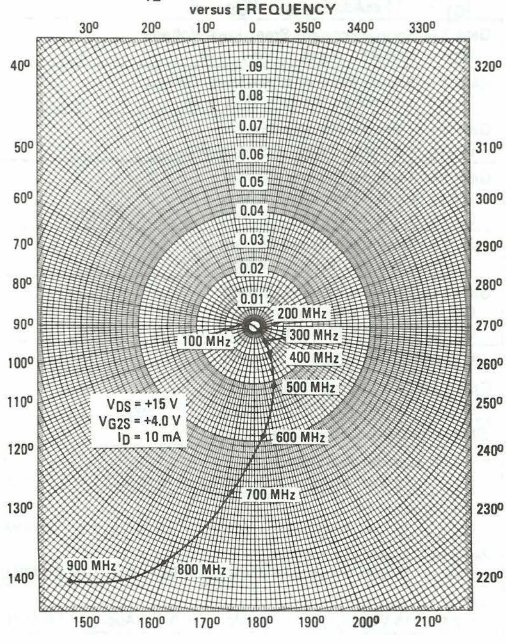


FIGURE 4 – S_{21}, FORWARD TRANSMISSION COEFFICIENT versus FREQUENCY

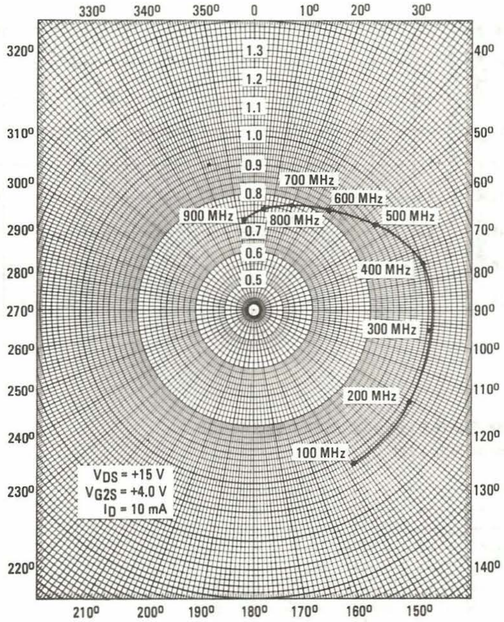
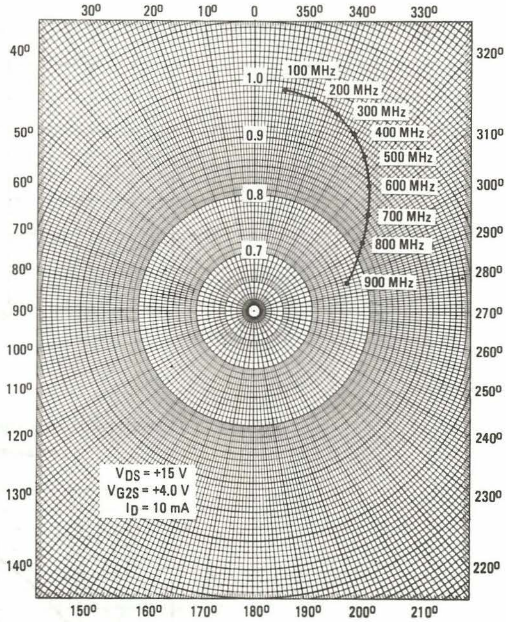


FIGURE 5 – S_{22}, OUTPUT REFLECTION COEFFICIENT versus FREQUENCY



TYPICAL COMMON-SOURCE ADMITTANCE PARAMETERS

(V_{DS} = 15 Vdc, V_{GS2} = 4.0 Vdc, I_D = 10 mAdc)

FIGURE 6 – Y_{11}, INPUT ADMITTANCE versus FREQUENCY

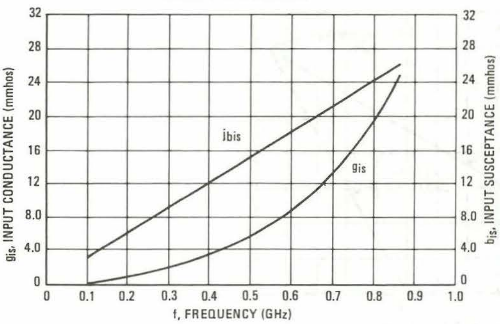


FIGURE 7 – Y_{12}, REVERSE TRANSFER ADMITTANCE versus FREQUENCY

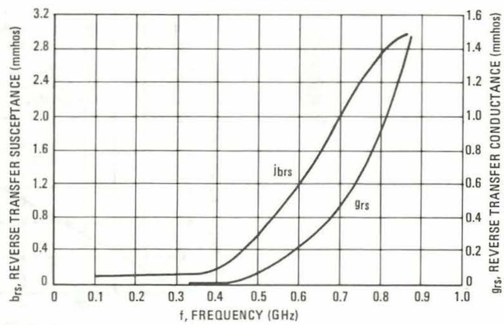


FIGURE 8 – Y_{21}, FORWARD TRANSFER ADMITTANCE versus FREQUENCY

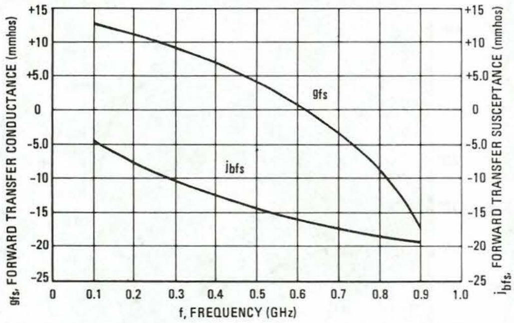
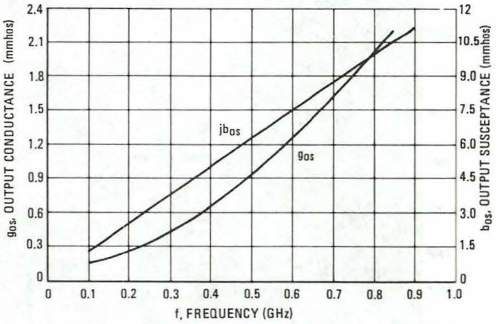


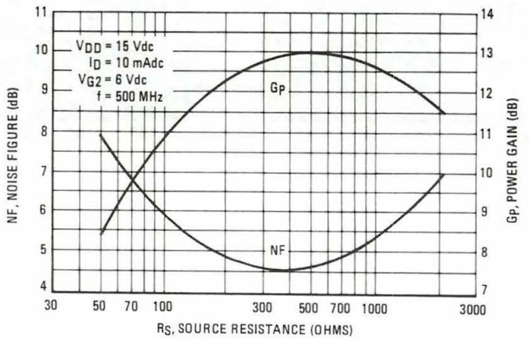
FIGURE 9 – Y_{22}, OUTPUT ADMITTANCE versus FREQUENCY



6

FIGURE 10 – POWER GAIN AND NOISE FIGURE versus SOURCE RESISTANCE

(See Schematic Figure 12)



The Test Circuit shown in Figure 12 was used to generate Power Gain and Noise Figure as a function of Source Resistance curves.

FIGURE 11 – THIRD ORDER INTERMODULATION DISTORTION

(See Schematic Figure 12)

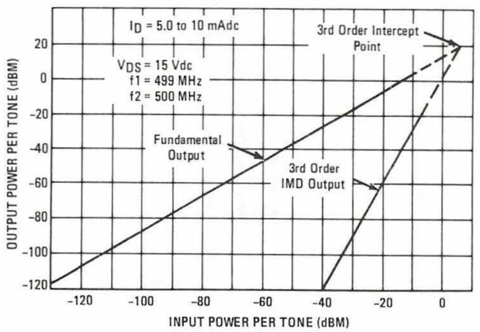
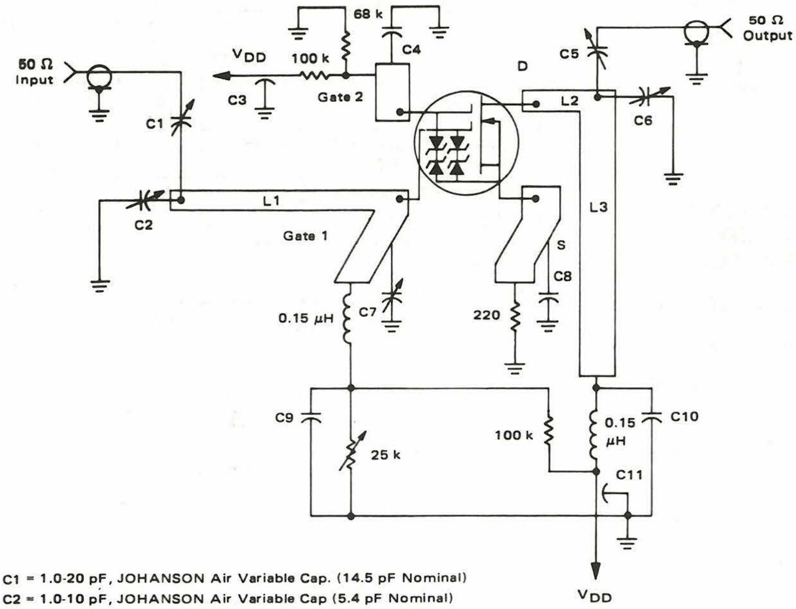


Figure 11 shows the typical third order intermodulation distortion (IMD) performance of the 3N209 and 3N210 at 500 MHz.

Both fundamental output and third order IMD output characteristics are plotted. The curves have been extrapolated to show the third order intermodulation output intercept point.

The performance is typical for I_D between 5.0 mAdc and 10 mAdc. The test circuit shown in Figure 12 was used to generate the IMD Data.

FIGURE 12 – TEST CIRCUIT FOR POWER GAIN, NOISE FIGURE AND THIRD ORDER INTERMODULATION DISTORTION



C1 = 1.0-20 pF, JOHANSON Air Variable Cap. (14.5 pF Nominal)
C2 = 1.0-10 pF, JOHANSON Air Variable Cap (5.4 pF Nominal)
C3, C11 = 470 pF, Low Inductance Feedthru Cap.
C4, C8, C9, C10 = 250 pF, Low Inductance, UNDERWOOD Cap. (J-101)
C5 = 0.4-6.0 pF, JOHANSON Air Variable Cap. (0.92 pF Nominal)
C6 = 1.0-10 pF, JOHANSON Air Variable Cap. (5.9 pF Nominal)
C7 = 1.0-10 pF, JOHANSON Air Variable Cap (3.0 pF Nominal)
L1 = 2.52 x 0.1 inches
L2 = 0.4 x 0.1 inches
L3 = 1.23 x 0.2 inches
} On 2 sided glass Teflon®, 1 oz. copper clad, 1/16″ $\epsilon_R = 2.55$

® Trademark of E.I. Dupont, DeNemours and Co., Inc.

3N211
3N212
3N213

CASE 20-03, STYLE 9
TO-72 (TO-206AF)

DUAL-GATE MOSFET VHF AMPLIFIER

N-CHANNEL — DEPLETION

Refer to MPF211 for graphs.

MAXIMUM RATINGS

Rating	Symbol	3N211 3N212	3N213	Unit
Drain-Source Voltage	V_{DS}	27	35	Vdc
Drain-Gate Voltage	V_{DG1} V_{DG2}	35 35	40 40	Vdc
Drain Current	I_D	50		mAdc
Gate Current	I_{G1} I_{G2}	±10 ±10		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.4		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 8.0		Watt mW/°C
Lead Temperature, 1/16″ From Seated Surface for 10 seconds	T_L	300		°C
Junction Temperature Range	T_J	−65 to +175		°C
Storage Temperature Range	T_{stg}	−65 to +175		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (I_D = 10 μAdc, V_{G1S} = V_{G2S} = −4.0 Vdc)	3N211,212 3N213	$V_{(BR)DSX}$	25 30	— —	Vdc
Instantaneous Drain-Source Breakdown Voltage)(1) (I_D = 10 μAdc, V_{G1S} = V_{G2S} = −4.0 Vdc)	3N211,212 3N213	$V_{(BR)DSX}$	27 35	— —	Vdc
Gate 1-Source Breakdown Voltage(2) (I_{G1} = ±10 mAdc, V_{G2S} = V_{DS} = 0)		$V_{(BR)G1SO}$	±6.0	—	Vdc
Gate 2-Source Breakdown Voltage(2) (I_{G2} = ±10 mAdc, V_{G1S} = V_{DS} = 0)		$V_{(BR)G2SO}$	±6.0	—	Vdc
Gate 1 Leakage Current (V_{G1S} = ±5.0 Vdc, V_{G2S} = V_{DS} = 0) (V_{G1S} = −5.0 Vdc, V_{G2S} = V_{DS} = 0, T_A = 150°C)		I_{G1SS}	— —	±10 −10	nAdc μAdc
Gate 2 Leakage Current (V_{G2S} = ±5.0 Vdc, V_{G1S} = V_{DS} = 0) (V_{G2S} = −5.0 Vdc, V_{G1S} = V_{DS} = 0, T_A = 150°C)		I_{G2SS}	— —	±10 −10	nAdc μAdc
Gate 1 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 20 μAdc)	3N211,213 3N212	$V_{G1S(off)}$	−0.5 −0.5	−5.5 −4.0	Vdc
Gate 2 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G1S} = 0, I_D = 20 μAdc)	3N211 3N212,213	$V_{G2S(off)}$	−0.2 −0.2	−2.5 −4.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(3) (V_{DS} = 15 Vdc, V_{G1S} = 0, V_{G2S} = 4.0 Vdc)		I_{DSS}	6.0	40	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance(4) (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, V_{G1S} = 0, f = 1.0 kHz)	3N211,212 3N213	$\|y_{fs}\|$	17 15	40 35	mmhos
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, f = 1.0 MHz)		C_{rss}	0.005	0.05	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DD} = 18 Vdc, V_{GG} = 7.0 Vdc, f = 200 MHz) (V_{DD} = 24 Vdc, V_{GG} = 6.0 Vdc, f = 45 MHz)	3N211 3N211,13	NF	— —	3.5 4.0	dB

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Common Source Power Gain		G_{ps}			dB
(V_{DD} = 18 Vdc, V_{GG} = 7.0 Vdc, f = 200 MHz)	3N211		24	35	
(V_{DD} = 24 Vdc, V_{GG} = 6.0 Vdc, f = 45 MHz)	3N211		29	37	
(V_{DD} = 24 Vdc, V_{GG} = 6.0 Vdc, f = 45 MHz)	3N213		27	35	
(V_{DD} = 18 Vdc, f_{LO} = 245 MHz, f_{RF} = 200 MHz)	3N212	G_c(6)	21	28	
Bandwidth		BW			MHz
(V_{DD} = 18 Vdc, V_{GG} = 7.0 Vdc, f = 200 MHz)	3N211		5.0	12	
(V_{DD} = 18 Vdc, f_{LO} = 245 MHz, f_{RF} = 200 MHz)	3N212		4.0	7.0	
(V_{DD} = 24 Vdc, V_{GG} = 6.0 Vdc, f = 45 MHz)	3N211,213		3.5	6.0	
Gain Control Gate-Supply Voltage(5)		$V_{GG(GC)}$			Vdc
(V_{DD} = 18 Vdc, ΔG_{ps} = −30 dB, f = 200 MHz)	3N211		—	−2.0	
(V_{DD} = 24 Vdc, ΔG_{ps} = −30 dB, f = 45 MHz)	2N211,213		—	±1.0	

(1) Measured after five seconds of applied voltage.

(2) All gate breakdown voltages are measured while the device is conducting rated gate current. This ensures that the gate-voltage limiting network is functioning properly.

(3) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.

(4) This parameter must be measured with bias voltages applied for less than 5 seconds to avoid overheating. The signal is applied to gate 1 with gate 2 at ac ground.

(5) ΔG_{ps} is defined as the change in G_{ps} from the value at V_{GG} = 7.0 Volts (3N211) and V_{GG} = 6.0 Volts (3N213).

(6) Power Gain Conversion. Amplitude at input from local oscillator is adjusted for maximum G_c.

6

BS107,A

CASE 29-02, STYLE 30
TO-92 (TO-226AA)

TMOS SWITCHING

N-CHANNEL — ENHANCEMENT

Refer to MFE9200 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	200	Vdc
Gate-Source Voltage	V_{GS}	±20	Vdc
Drain Current Continuous(1) Pulsed(2)	 I_D I_{DM}	 250 500	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.6	Watts
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to 150	°C

(1) The Power Dissipation of the package may result in a lower continuous drain current.
(2) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = 130 V, V_{GS} = 0)	I_{DSS}	—	—	30	nAdc
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 100 μA)	$V_{(BR)DSX}$	200	—	—	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)	I_{GSS}	—	0.01	10	nAdc
ON CHARACTERISTICS*					
Gate Threshold Voltage (I_D = 1.0 mA, V_{DS} = V_{GS})	$V_{GS(Th)}$	1.0	—	3.0	Vdc
Static Drain-Source On Resistance	$r_{DS(on)}$				Ohms
BS107					
(V_{GS} = 2.6 V, I_D = 20 mA)					
(V_{GS} = 10 V, I_D = 200 mA)		—	—	28	
BS107A		—	—	14	
(V_{GS} = 10 Vdc)					
(I_D = 100 mA)		—	4.5	6.0	
(I_D = 250 mA)		—	4.8	6.4	
SMALL-SIGNAL CHARACTERISTICS					
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	72	90	pF
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	2.8	3.5	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	15	20	pF
Forward Transconductance (V_{DS} = 25 V, I_D = 250 mA)	g_{fs}	200	400	—	mmhos
SWITCHING CHARACTERISTICS					
Turn-On Time	t_{on}	—	6.0	15	ns
Turn-Off Time	t_{off}	—	12	15	ns

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

BS170

CASE 29-02, STYLE 30
TO-92 (TO-226AA)

TMOS FET
SWITCHING

N-CHANNEL — ENHANCEMENT

Refer to 2N6659 for graphs.

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	60	Vdc
Gate-Source Voltage	V_{GS}	±20	Vdc
Drain Current(1)	I_D	0.5	Adc
Total Device Dissipation @ $T_C = 25°C$	P_D	0.83	Watt
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

(1) The Power Dissipation of the package may result in a lower continuous drain current.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate Reverse Current ($V_{GS} = 15$ V, $V_{DS} = 0$)	I_{GSS}	—	0.01	10	nAdc
Drain-Source Breakdown Voltage ($V_{GS} = 0$, $I_D = 100$ μA)	$V_{(BR)DSS}$	60	90	—	Vdc
ON CHARACTERISTICS(2)					
Gate Threshold Voltage ($V_{DS} = V_{GS}$, $I_D = 1.0$ mA)	$V_{GS(Th)}$	0.8	2.0	3.0	Vdc
Static Drain-Source On Resistance ($V_{GS} = 10$ V, $I_D = 200$ mA)	$r_{DS(on)}$	—	1.8	5.0	Ohms
Drain Cutoff Current ($V_{DS} = 25$ V, $V_{GS} = 0$ V)	$I_{D(off)}$	—	—	0.5	μA
Forward Transconductance ($V_{DS} = 10$ V, $I_D = 250$ mA)	g_{fs}	—	200	—	mmhos
SMALL-SIGNAL CHARACTERISTICS					
Input Capacitance ($V_{DS} = 10$ V, $V_{GS} = 0$, f = 1.0 MHz)	C_{iss}	—	60	—	pF
SWITCHING CHARACTERISTICS					
Turn-On Time ($I_D = 0.2$ A) See Figure 1	t_{on}	—	4.0	10	ns
Turn-Off Time ($I_D = 0.2$ A) See Figure 1	t_{off}	—	4.0	10	ns

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

RESISTIVE SWITCHING

FIGURE 1 — SWITCHING TEST CIRCUIT

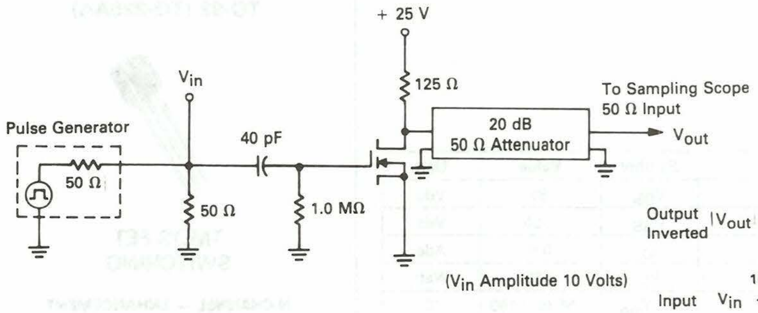


FIGURE 2 — SWITCHING WAVEFORMS

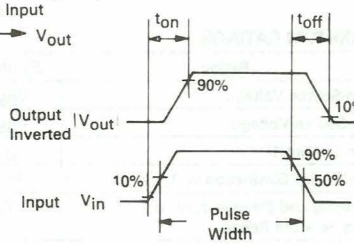


FIGURE 3 — $V_{GS(th)}$ NORMALIZED versus TEMPERATURE

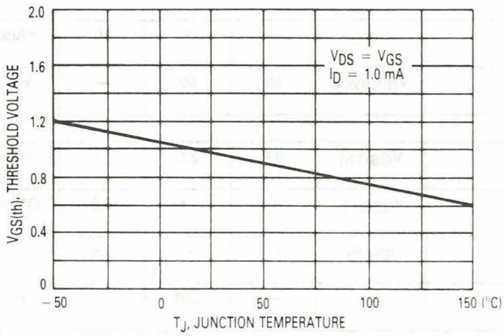


FIGURE 4 — ON-REGION CHARACTERISTICS

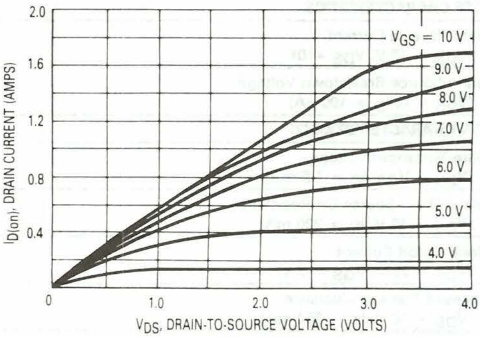


FIGURE 5 — OUTPUT CHARACTERISTICS

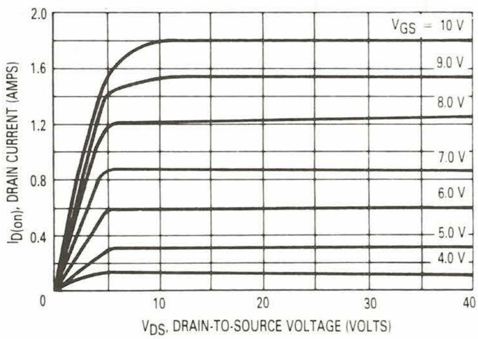
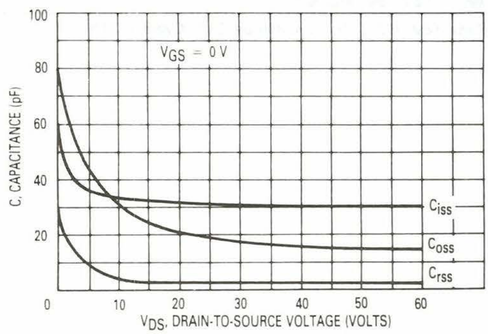


FIGURE 6 — CAPACITANCE versus DRAIN-TO-SOURCE VOLTAGE



J107, J108
J109, J110

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
GENERAL-PURPOSE
TRANSISTOR

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	−25	Vdc
Gate-Source Voltage	V_{GS}	−25	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Junction Temperature Range	T_J	135	°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (V_{DS} = 0, I_G = −10 μAdc)		$V_{(BR)GSS}$	−25	—	—	Vdc
Gate Reverse Current		I_{GSS}				nAdc
(V_{GS} = −15 Vdc, V_{DS} = 0)			—	—	−3.0	
(V_{GS} = −15 Vdc, V_{DS} = 0, T_A = 100°C)			—	—	−200	
Gate Source Cutoff Voltage		$V_{GS(off)}$				Vdc
(V_{DS} = 15 Vdc, I_D = 10 nAdc)	J107		−0.5	—	−4.5	
	J108		−3.0	—	−10	
	J109		−2.0	—	−6.0	
	J110		−0.5	—	−4.0	
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current(1)		I_{DSS}				mAdc
(V_{DS} = 15, V_{GS} = 0)	J107		100	—	—	
	J108		80	—	—	
	J109		40	—	—	
	J110		10	—	—	
Drain-Source On-Resistance		$r_{DS(on)}$				ohms
(V_{DS} < 0.1 V, V_{GS} = 0 V)	J107		—	—	8.0	
	J108		—	—	8.0	
	J109		—	—	12	
	J110		—	—	18	
SMALL-SIGNAL CHARACTERISTICS						
Drain Gate + Source Gate On-Capacitance (V_{DS} = 0 Vdc, V_{GS} = 0, f = 1.0 MHz)		$C_{dg(on)}$ + $C_{sg(on)}$	—	—	85	pF
Drain Gate Off-Capacitance (V_{DS} = 0 Vdc, V_{GS} = −10 V, f = 1.0 MHz)		$C_{dg(off)}$	—	—	15	pF
Source Gate Off-Capacitance (V_{DS} = 0 Vdc, V_{GS} = −10 V, f = 1.0 MHz)		$C_{sg(off)}$	—	—	15	pF

(1) Pulse Duration 300 μs, Duty Cycle ≤ 2.0%.

6

FIGURE 1 — COMMON SOURCE INPUT CAPACITANCE versus GATE-SOURCE VOLTAGE

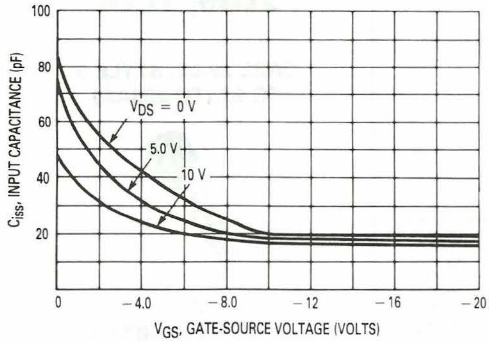


FIGURE 2 — COMMON SOURCE REVERSE FEEDBACK CAPACITANCE versus GATE-SOURCE VOLTAGE

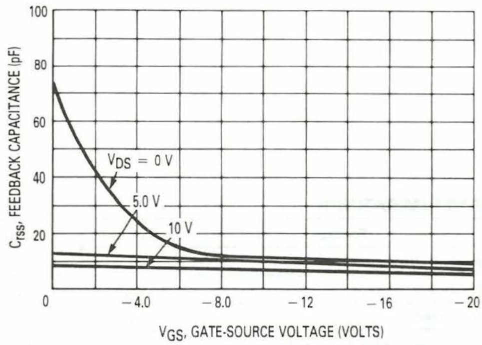


FIGURE 3 — ON-RESISTANCE versus GATE-SOURCE CUTOFF VOLTAGE

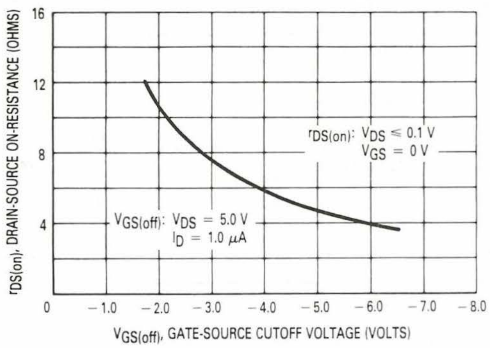


FIGURE 4 — OUTPUT CHARACTERISTIC

$V_{GS(off)} = -2.0$ V

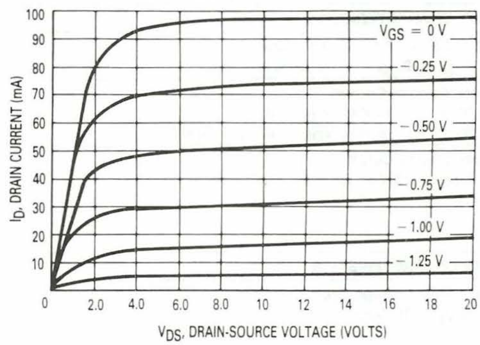


FIGURE 5 — OUTPUT CHARACTERISTIC

$V_{GS(off)} = -3.0$ V

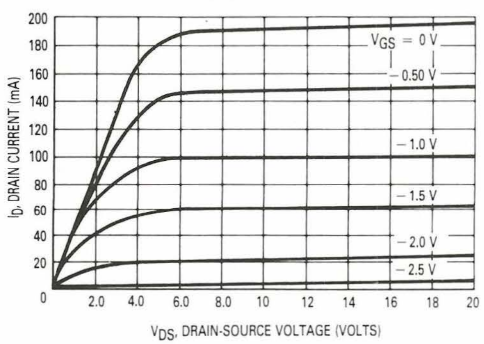


FIGURE 6 — OUTPUT CHARACTERISTIC

$V_{GS(off)} = -4.0$ V

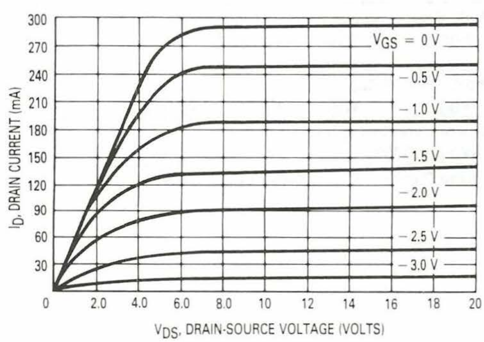
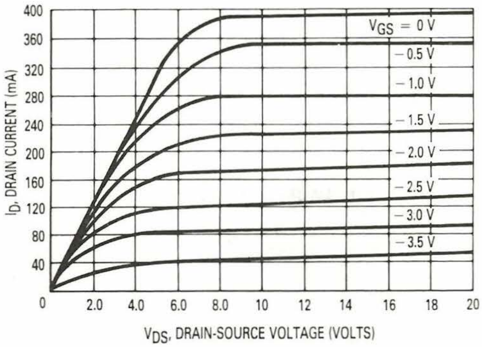


FIGURE 7 — OUTPUT CHARACTERISTIC

$V_{GS(off)} = -5.0$ V



6

J111
J112
J113

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
CHOPPER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	−35	Vdc
Gate-Source Voltage	V_{GS}	−35	Vdc
Gate Current	I_G	50	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.68	mW mW/°C
Lead Temperature	T_L	300	°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = −1.0 μA)		$V_{(BR)GSS}$	35	—	Vdc
Gate Reverse Current (V_{GS} = −15 V)		I_{GSS}	—	−1.0	nA
Gate Source Cutoff Voltage (V_{DS} = 5.0 V, I_D = 1.0 μA)	J111 J112 J113	$V_{GS(off)}$	−3.0 −1.0 −0.5	−10 −5.0 −3.0	V
Drain-Cutoff Current (V_{DS} = 5.0 V, V_{GS} = −10 V)		$I_{D(off)}$	—	1.0	nA
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current* (V_{DS} = 15 V)	J111 J112 J113	I_{DSS}	20 5.0 2.0	— — —	mA
Static Drain-Source On Resistance (V_{DS} = 0.1 V)	J111 J112 J113	$r_{DS(on)}$	— — —	30 50 100	Ohms
Drain Gate and Source Gate On-Capacitance (V_{DS} = V_{GS} = 0, f = 1.0 MHz)		$C_{dg(on)}$ + $C_{sg(on)}$	—	28	pF
Drain Gate Off-Capacitance (V_{GS} = −10 V, f = 1.0 MHz)		$C_{dg(off)}$	—	5.0	pF
Source Gate Off-Capacitance (V_{GS} = −10 V, f = 1.0 MHz)		$C_{sg(off)}$	—	5.0	pF

*Pulse Width = 300 μsec, Duty Cycle = 3.0%.

J174
J175
J176
J177

CASE 29-02, STYLE 30
TO-92 (TO-226AA)

JFET
CHOPPER TRANSISTOR

P-CHANNEL — DEPLETION

Refer to MPF970 for graphs.

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Gate Current	I_G	50	mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

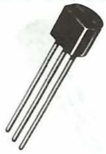
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = 1.0\ \mu A$)		$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current ($V_{GS} = 20$ Volts)		I_{GSS}	—	1.0	nA
Gate Source Cutoff Voltage ($V_{DS} = -15$ V, $I_D = -10$ nA)	J174 J175 J176 J177	$V_{GS(off)}$	5.0 3.0 1.0 0.8	10 6.0 4.0 2.5	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current ($V_{DS} = -15$ V)	J174 J175 J176 J177	I_{DSS}*	−2.0 −7.0 −2.0 −1.5	−100 −60 −25 −20	mA
Static Drain-Source On Resistance ($V_{DS} \leq -0.1$ Volt)	J174 J175 J176 J177	$r_{DS(on)}$	— — — —	85 125 250 300	Ω

*Pulse Width = 300 μs, Duty Cycle ≤ 3.0%.

J201
J202
J203

CASE 29-02, STYLE 5
TO-92 (TO-226AA)



JFET
LOW FREQUENCY/LOW NOISE

N-CHANNEL — DEPLETION

Refer to 2N4220 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Gate-Source Voltage	V_{GS}	40	Vdc
Gate Current	I_G	50	mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	310 2.82	mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = -1.0\ \mu A$)		$V_{(BR)GSS}$	−40	—	Vdc
Gate Reverse Current ($V_{GS} = -20$ V)		I_{GSS}	—	−100	pA
Gate Source Cutoff Voltage ($V_{DS} = 20$ V, $I_D = 10$ nA)	J201 J202 J203	$V_{GS(off)}$	−0.3 −0.8 −2.0	−1.5 −4.0 −10.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current ($V_{DS} = 20$ V)	J201 J202 J203	I_{DSS}*	0.2 0.9 4.0	1.0 4.5 20.0	mA
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance ($V_{DS} = 20$ V, f = 1.0 kHz)	J201 J202 J203	$\|y_{fs}\|$*	500 1000 1500	— — —	μmhos

*Pulse Width ≤ 2.0 msec.

J270
J271

CASE 29-02, STYLE 30
TO-92 (TO-226AA)

JFET
CHOPPER TRANSISTOR

P-CHANNEL — DEPLETION

Refer to MPF970 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Gate Current	I_G	50	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 3.27	mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μA)		$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current (V_{GS} = 20 Volts)		I_{GSS}	—	200	pA
Gate Source Cutoff Voltage (V_{DS} = −15 V, I_D = −1.0 nA)	J270 J271	$V_{GS(off)}$	0.5 1.5	2.0 4.5	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = −15 V)	J270 J271	I_{DSS}*	−2.0 −6.0	−15 −50	mA
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = −15 V, f = 1.0 kHz)	J270 J271	$\|y_{fs}\|$	6000 8000	15000 18000	μmhos
Output Admittance (V_{DS} = −15 V, f = 1.0 kHz)	J270 J271	$\|y_{os}\|$	— —	200 500	μmhos
Input Capacitance (V_{DS} = −15 V, f = 1.0 MHz)		C_{iss}	—	32	pF
Reverse Transfer Capacitance (V_{DS} = −15 V, f = 1.0 MHz)		C_{rss}	—	8.0	pF

*Pulse Width ≤ 2.0 ms.

6

J300

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
HIGH FREQUENCY AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	−25	Vdc
Gate Current	I_G	10	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 3.5	mW mW/°C
Lead Temperature (1/16″ from Case for 10 Seconds)	T_L	300	°C
Junction Temperature Range	T_J	−55 to +150	°C
Storage Temperature Range	T_{stg}	−55 to +150	°C

6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = −1.0 μA, V_{DS} = 0)	$V_{(BR)GSS}$	−25	—	Vdc
Gate Reverse Current (V_{GS} = −15 V, V_{DS} = 0)	I_{GSS}	—	500	pA
Gate Source Cutoff Voltage (V_{DS} = 10 V, I_D = 1.0 mA)	$V_{GS(off)}$	−1.0	−6.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V_{DS} = 10 V, V_{GS} = 0)	I_{DSS}	6.0	30	mA
Gate-Source Forward Voltage (V_{DS} = 0, I_G = 1.0 mA)	$V_{GS(f)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 10 V, I_D = 5.0 mA, f = 1.0 kHz)	$\|y_{fs}\|$	4500	9000	μmhos
Output Admittance (V_{DS} = 10 V, I_D = 5.0 mA, f = 1.0 kHz)	$\|y_{os}\|$	—	200	μmhos
Input Capacitance (V_{DS} = 10 V, I_D = 5.0 mA, f = 1.0 MHz)	C_{iss}	—	5.5	pF
Reverse Transfer Capacitance (V_{DS} = 10 V, I_D = 5.0 mA, f = 1.0 MHz)	C_{rss}	—	1.7	pF

J304
J305

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
HIGH FREQUENCY
AMPLIFIER

N-CHANNEL — DEPLETION

6

MAXIMUM RATINGS

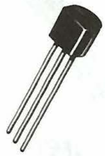
Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	−30	Vdc
Gate-Source Voltage	V_{GS}	−30	Vdc
Gate Current	I_G	10	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 3.5	mW mW/°C
Lead Temperature (1/16″ from Case for 10 Seconds)	T_L	300	°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μA, V_{DS} = 0)		$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current (V_{GS} = −20 V, V_{DS} = 0)		I_{GSS}	—	100	pA
Gate Source Cutoff Voltage (V_{DS} = 15 V, I_D = 1.0 nA)	J304 J305	$V_{GS(off)}$	−2.0 −0.5	−6.0 −3.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = 15 V, V_{GS} = 0)	J304 J305	I_{DSS}	5.0 1.0	15 8.0	mA
SMALL-SIGNAL CHARACTERISTICS					
Output Admittance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 kHz)		$\|y_{os}\|$	—	50	μmhos
Forward Transconductance (V_{DS} = 15 V, V_{GS} = 0, f = 1.0 kHz)	J304 J305	$Re(y_{fs})$	4500 3000	7500 —	μmhos

J308
J309
J310

CASE 29-02, STYLE 5
TO-92 (TO-226AA)



JFET
VHF/UHF AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 3.5	mW mW/°C
Junction Temperature Range	T_J	−55 to +125	°C
Storage Temperature Range	T_{stg}	−55 to +150	°C

Refer to U308 for graphs.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = −1.0 μA, V_{DS} = 0)		$V_{(BR)GSS}$	−25	—	—	Vdc
Gate Reverse Current (V_{GS} = −15 V, V_{DS} = 0, T_A = 25°C)		I_{GSS}	—	—	−1.0	nA
(V_{GS} = −15 V, V_{DS} = 0, T_A = +125°C)			—	—	−1.0	μA
Gate Source Cutoff Voltage (V_{DS} = 10 V, I_D = 1.0 nA)	J308	$V_{GS(off)}$	−1.0	—	−6.5	Vdc
	J309		−1.0	—	−4.0	
	J310		−2.0	—	−6.5	
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 10 V, V_{GS} = 0)	J308	I_{DSS}	12	—	60	mA
	J309		12	—	30	
	J310		24	—	60	
Gate-Source Forward Voltage (V_{DS} = 0, I_G = 1.0 mA)		$V_{GS(f)}$	—	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Common-Source Input Conductance (V_{DS} = 10 V, I_D = 10 mA, f = 100 MHz)	J308	$Re(y_{is})$	—	0.7	—	mmhos
	J309		—	0.7	—	
	J310		—	0.5	—	
Common-Source Output Conductance (V_{DS} = 10 V, I_D = 10 mA, f = 100 MHz)		$Re(y_{os})$	—	0.25	—	mmhos
Common-Gate Power Gain (V_{DS} = 10 V, I_D = 10 mA, f = 100 MHz)		G_{pg}	—	16	—	dB
Common-Source Forward Transconductance (V_{DS} = 10 V, I_D = 10 mA, f = 100 MHz)		$Re(y_{fs})$	—	12	—	mmhos
Common-Gate Input Conductance (V_{DS} = 10 V, I_D = 10 mA, f = 100 MHz)		$Re(y_{ig})$	—	12	—	mmhos
Common-Gate Forward Transconductance (V_{DS} = 10 V, I_D = 10 mA, f = 1.0 kHz)	J308	g_{fs}	8000	—	20000	μmhos
	J309		10000	—	20000	
	J310		8000	—	18000	
Common-Gate Output Conductance (V_{DS} = 10 V, I_D = 10 mA, f = 1.0 kHz)	J308	g_{os}	—	—	200	μmhos
	J309		—	—	150	
	J310		—	—	200	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Common-Gate Forward Transconductance (V_{DS} = 10 V, I_D = 10 mA, f = 1.0 kHz)	J308	g_{fg}	—	13000	—	μmhos
	J309		—	13000	—	
	J310		—	12000	—	
Common-Gate Output Conductance (V_{DS} = 10 V, I_D = 10 mA, f = 1.0 kHz)	J308	g_{og}	—	150	—	μmhos
	J309		—	100	—	
	J310		—	150	—	
Gate-Drain Capacitance (V_{DS} = 0, V_{GS} = −10 V, f = 1.0 MHz)		C_{gd}	—	1.8	2.5	pF
Gate-Source Capacitance (V_{DS} = 0, V_{GS} = −10 V, f = 1.0 MHz)		C_{gs}	—	4.3	5.0	pF

FUNCTIONAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Noise Figure (V_{DS} = 10 V, I_D = 10 mA, f = 450 MHz)	NF	—	1.5	—	dB
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 10 V, I_D = 10 mA, f = 100 Hz)	$\bar{e}_n$	—	10	—	$nV/\sqrt{Hz}$

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 3.0%.

6

JF1033B
JF1033S
JF1033Y

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
HIGH FREQUENCY AMPLIFIER

N-CHANNEL DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	20	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Drain Current	I_D	20	mA
Forward Gate Current	I_{GF}	10	mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	310 2.82	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150	°C

6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = -10\ \mu A$)	$V_{(BR)GSS}$	−25	—	Vdc
Drain-Source Breakdown Voltage ($I_D = 10\ \mu A$)	$V_{(BR)DGO}$	20	—	Vdc
Gate Reverse Current ($V_{GS} = -10$ V, $V_{DS} = 0$)	I_{GSS}	—	−100	nA
Gate Source Cutoff Voltage ($V_{DS} = 10$ V, $I_D = 10\ \mu A$)	$V_{GS(off)}$	−1.0	−8.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current ($V_{DS} = 10$ V, $V_{GS} = 0$) JF1033Y JF1033B JF1033S	I_{DSS}	2.5 5.0 10.0	6.0 12.0 20.0	mA
SMALL-SIGNAL CHARACTERISTICS				
Forward Transconductance ($V_{DS} = 10$ V, $V_{GS} = 0$, f = 1.0 kHz)	$Re(y_{fs})$	4.5	13.0	mmhos
FUNCTIONAL CHARACTERISTICS				
Noise Figure ($V_{DS} = 10$ V, $V_{GS} = 0$, f = 100 MHz)	NF	—	2.5	dB

MFE120
MFE121
MFE122

CASE 20-03, STYLE 9
TO-72 (TO-206AF)

DUAL-GATE MOSFET
VHF AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	+25	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.7	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

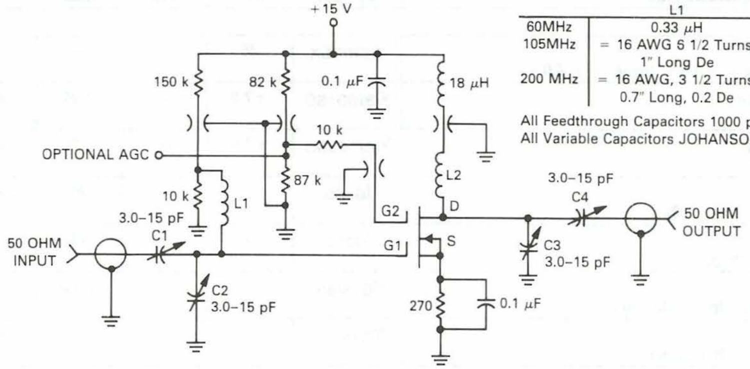
Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain-Source Breakdown Voltage (I_D = 100 μAdc, V_S = 0, V_{G1S} = −4.0 V, V_{G2S} = +4.0 V)		$V_{(BR)DSX}$	25	—	—	Vdc
Gate 1-Source Breakdown Voltage (I_{G1} = ±10 μAdc, V_{G2S} = 0)		$V_{(BR)G1SO}$	±7.0	—	±20	Vdc
Gate 2-Source Breakdown Voltage (I_{G2} = ±10 μAdc, V_{G2S} = 0)		$V_{(BR)G2SO}$	±7.0	—	±20	Vdc
Gate 1 Leakage Current (V_{G1S} = +6.0 Vdc, V_{G2S} = 0, V_{DS} = 0)		I_{G1SS}	—	—	20	nAdc
Gate 2 Leakage Current (V_{G2S} = +6.0 Vdc, V_{G1S} = 0, V_{DS} = 0)		I_{G2SS}	—	—	20	nAdc
Gate 1 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 200 μAdc)		$V_{G1S(off)}$	—	—	−4.0	Vdc
Gate 2 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G1S} = 0, I_D = 200 μAdc)		$V_{G2S(off)}$	—	—	−4.0	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current (V_{DS} = 15 Vdc, V_{G1S} = 0, V_{G2S} = 4.0 Vdc)	MFE120 MFE121 MFE122	I_{DSS}	2.0 5.0 2.0	7.0 10 9.0	18 30 20	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (Gate 1 to Drain) (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, f = 1.0 kHz)	MFE120,22 MFE121	$\|Y_{fs}\|$	8000 10,000	— —	18,000 20,000	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = I_{DSS}, f = 1.0 MHz)	MFE120,22 MFE121	C_{iss}	— —	4.5 4.5	7.0 6.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc, f = 1.0 MHz)		C_{rss}	—	0.023	—	pF
Output Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = I_{DSS}, f = 1.0 MHz)	MFE120,22 MFE121	C_{oss}	— —	2.5 2.5	4.0 3.5	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
FUNCTIONAL CHARACTERISTICS						
Noise Figure (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc, Z_S is optimized for NF) (f = 105 MHz — Figure 1) (f = 60 MHz — Figure 3) (f = 200 MHz — Figure 3)	 MFE120 MFE121 MFE121	NF	 — — —	 2.9 2.6 2.6	 5.0 5.0 5.0	dB
Common Source Power Gain (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc, Z_S is optimized for NF) (f = 105 MHz — Figure 1) (f = 60 MHz — Figure 3) (f = 200 MHz — Figure 3)	 MFE120 MFE121 MFE121	G_{ps}	 17 20 17	 19.6 27.8 18.6	 — — —	dB
Level of Unwanted Signal for 1.0% Cross Modulation (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc)		—	—	100	—	mV
Common-Source Conversion Power Gain (Gate 1 Injection, Figure 2) (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, Local Oscillator Voltage = 925 mVrms) (Signal Frequency = 60 MHz, Local Oscillator Frequency = 104 MHz) (Signal Frequency = 200 MHz, Local Oscillator Frequency = 244 MHz)	 MFE122 MFE122	G_c	 15 12	 16.5 13.3	 — —	dB

6

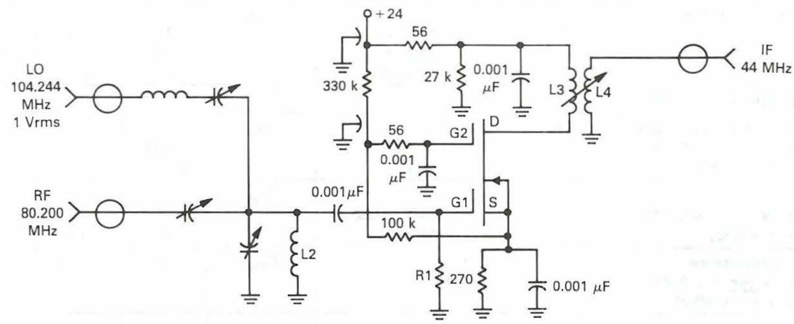
FIGURE 1 — 60, 105 AND 200 MHz POWER GAIN AND NOISE FIGURE TEST CIRCUIT



	L1	L2
60MHz 105MHz	0.33 µH = 16 AWG 6 1/2 Turns, 1" Long De	0.47 µH = 16 AWG 5 1/4 Turns, 1" Long, 7/16" De
200 MHz	= 16 AWG, 3 1/2 Turns, 0.7" Long, 0.2 De	= 16 AWG, 4 1/2 Turns, 0.65" Long, 0.2" De

All Feedthrough Capacitors 1000 pf.
All Variable Capacitors JOHANSON JMC2951, 3.0–15 pF

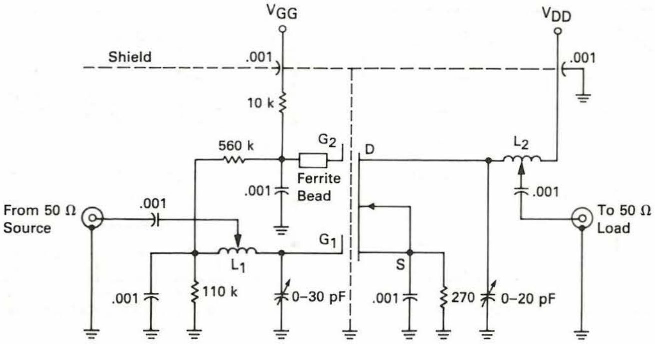
FIGURE 2 — 60 AND 200 MHz CONVERSION GAIN TEST CIRCUIT



	R1	L1	L2	L3	L4
60 MHz	10 k	10 Turns = 22 Enameled on MILLER 4500 4 Core	0.33 µH DELEVAN	15 Turns = 25 Enameled on MILLER 4500 1 Core	4 Turns = 20 Enameled on Sure Core as L3
200 MHz	1.0 k	3 1/2 Turns = 18.1/4" De. 1/2" Long	2 1/2 Turns = 15.3/8" De. 1/2" Long	15 Turns = 26 Enameled on MILLER 4500 1 Core	4 Turns = 26 Enameled on Sure Core as L3

All Feedthrough Capacitors 1000 pf.
All Variable Capacitors JOHANSON JMC2951, 3.0–15 pF

FIGURE 3 – 60 AND 200 MHz CONVERSION POWER GAIN



L_1 2½ T #18, ¼″ diameter center tapped
L_2 3½ T #18, 5/16″ diameter tapped ½T from cold end
C = μF unless otherwise specified

COMMON-SOURCE ADMITTANCE PARAMETERS

(V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc)

FIGURE 4 – INPUT ADMITTANCE

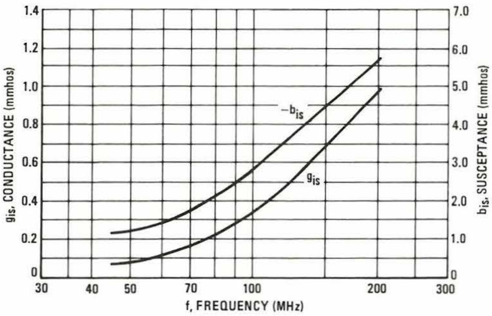


FIGURE 5 – REVERSE TRANSFER ADMITTANCE

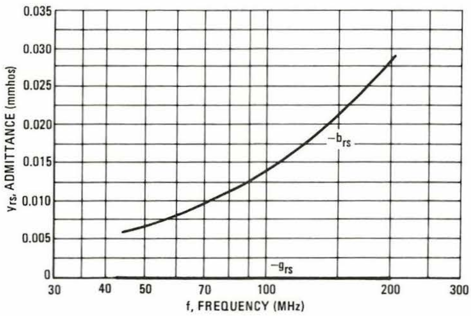


FIGURE 6 – FORWARD TRANSFER ADMITTANCE

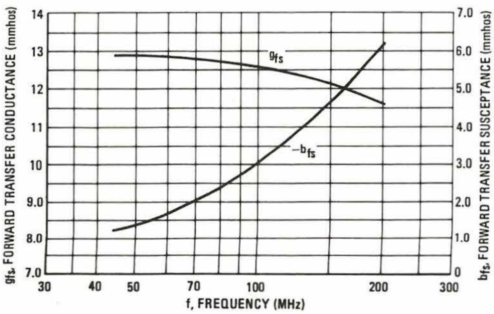


FIGURE 7 – OUTPUT ADMITTANCE

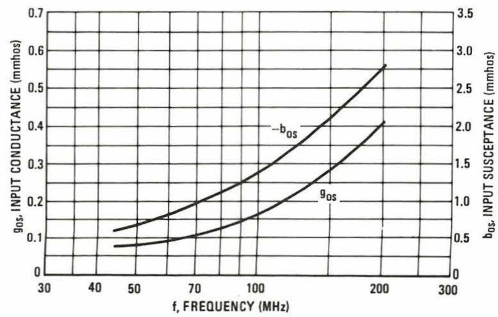


FIGURE 8 – GAIN REDUCTION

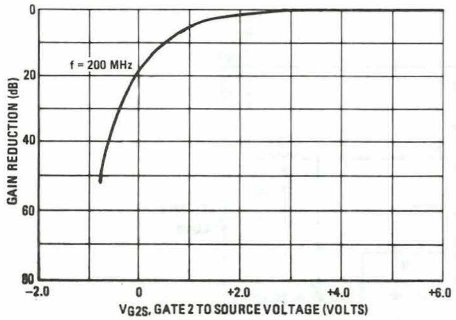
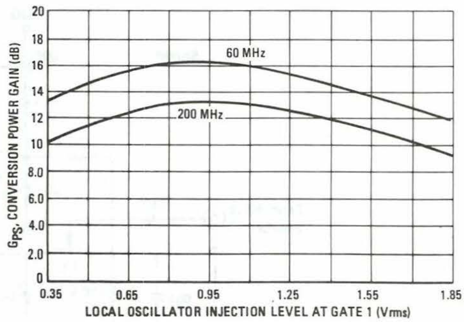


FIGURE 9 – CONVERSION POWER GAIN



6

MFE140

CASE 20-03, STYLE 9
TO-72 (TO-206AF)

DUAL-GATE MOSFET FM AMPLIFIER

N-CHANNEL — DEPLETION

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Gate-Source Voltage	V_{GS}	±7.0	Vdc
Drain Current	I_D	30	mAdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300	mW
Operating and Storage Channel Temperature Range	$T_{channel}$, T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (I_D = 10 μAdc, V_S = 0, V_{G1} = −4.0 Vdc, V_{G2} = +4.0 Vdc)	$V_{(BR)DSX}$	25	—	—	Vdc
Gate 1-Source Breakdown Voltage (I_{G1} = ±10 μAdc, V_{G2S} = 0)	$V_{(BR)G1SO}$	±7.0	—	±20	Vdc
Gate 2-Source Breakdown Voltage (I_{G2} = ±10 μAdc, V_{G2S} = 0)	$V_{(BR)G2SO}$	±7.0	—	±20	Vdc
Gate 1 Leakage Current (V_{G1S} = ±6.0 Vdc, V_{G2S} = 0, V_{DS} = 0)	I_{G1SS}	—	—	20	nAdc
Gate 2 Leakage Current (V_{G2S} = ±6.0 Vdc, V_{G1S} = 0, V_{DS} = 0)	I_{G2SS}	—	—	20	nAdc
Gate 1 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 200 μAdc)	$V_{G1S(off)}$	—	—	−4.0	Vdc
Gate 2 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G1S} = 0, I_D = 200 μAdc)	$V_{G2S(off)}$	—	—	−4.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = 15 Vdc, V_{G2S} = 0, V_{G2S} = 4.0 Vdc)	I_{DSS}	3.0	10	30	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (Gate 1 connected to Drain) (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, f = 1.0 kHz)	$\|y_{fs}\|$	10	—	20	mmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = I_{DSS}, f = 1.0 MHz)	C_{iss}	—	4.5	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = I_{DSS}, = 1.0 MHz)	C_{rss}	—	0.023	0.05	pF
Output Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = I_{DSS}, f = 1.0 MHz)	C_{oss}	—	2.5	4.0	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (Figure 8) (See Test Circuit in Figure 11)	NF	—	2.5	3.5	dB
Common Source Power Gain (Figure 7) (See Test Circuit in Figure 11)	G_{ps}	20	23	—	dB
Level of Unwanted Signal for 1.0% Cross Modulation (Figure 10) (See Test Circuit in Figure 11)	—	—	45	—	mV

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Common-Source Conversion Power Gain (Gate 1 or Gate 2 Injection, Figure 12) (See Test Circuit in Figure 13) (Signal Frequency = 100 MHz, Local Oscillator Frequency = 110.7 MHz)	G_c	15	18.5	—	dB
1/2 I.F. Rejection (See Test Circuit in Figure 13)	1/2 I_{FREJ}	—	50	—	dB

COMMON-SOURCE ADMITTANCE PARAMETERS

(V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc)

FIGURE 1 — INPUT ADMITTANCE

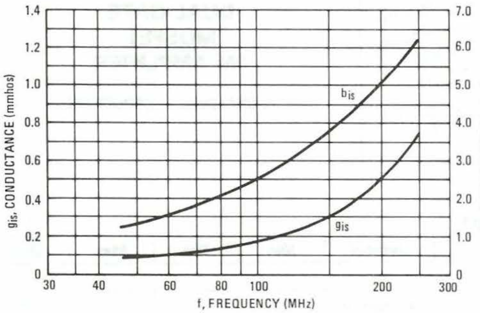


FIGURE 2 — REVERSE TRANSFER ADMITTANCE

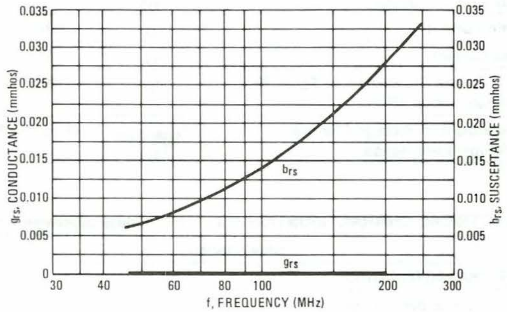


FIGURE 3 — FORWARD TRANSFER ADMITTANCE

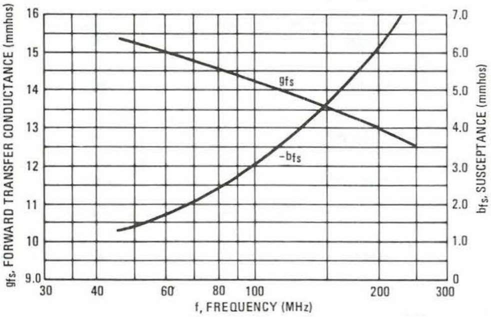
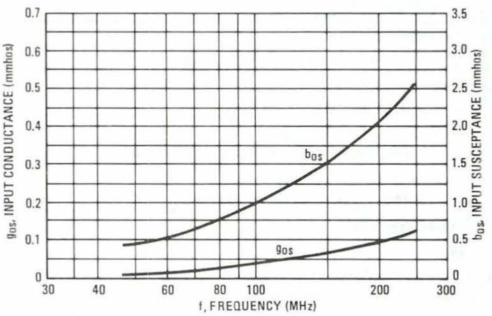


FIGURE 4 — OUTPUT ADMITTANCE



FORWARD TRANSFER ADMITTANCE

(V_{DS} = 15 Vdc, f = 1.0 kHz)

FIGURE 5 — GATE 1

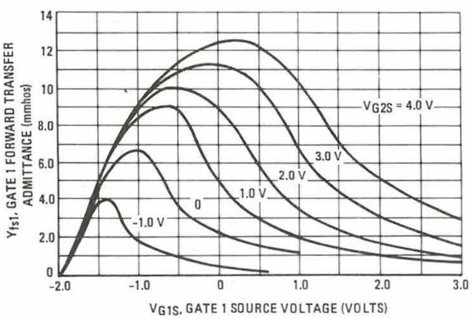


FIGURE 6 — GATE 2

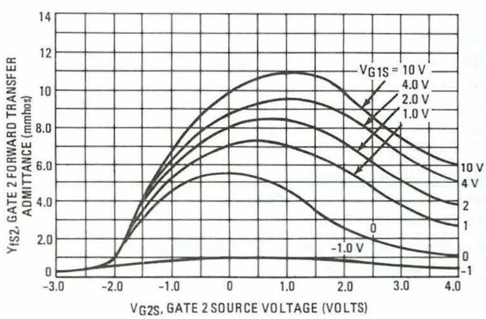


FIGURE 7 — POWER GAIN

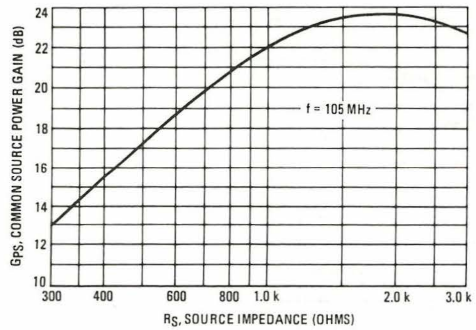


FIGURE 8 — NOISE FIGURE

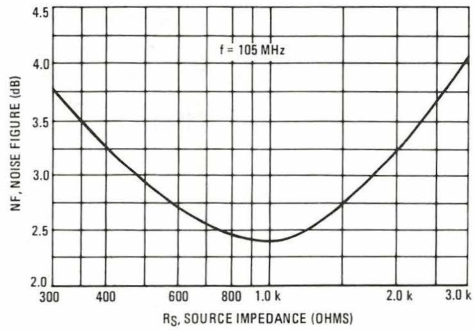


FIGURE 9 — GAIN REDUCTION

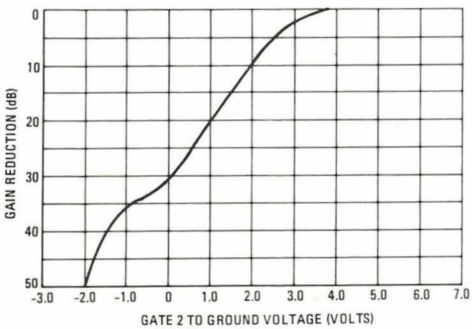


FIGURE 10 — CROSS MODULATION

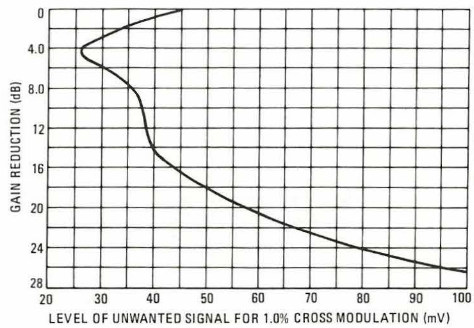
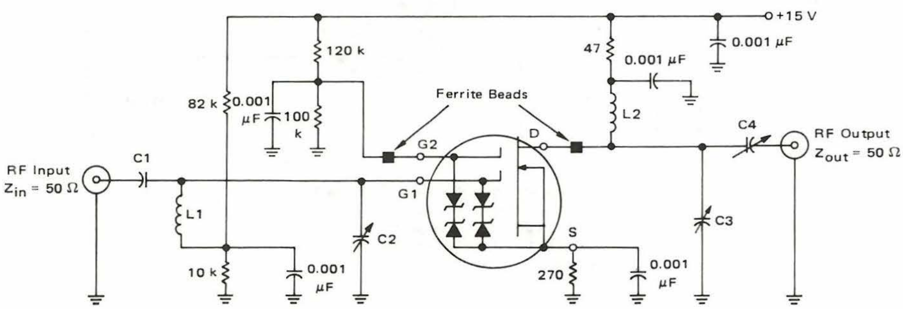


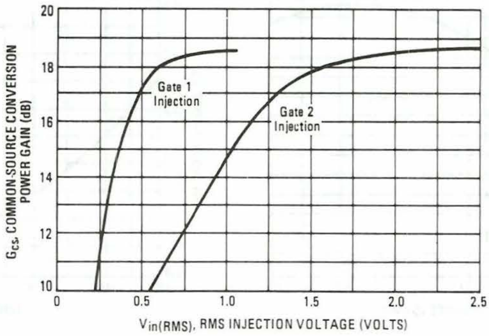
FIGURE 11 — 105 MHz POWER GAIN AND NOISE FIGURE TEST CIRCUIT



The following component values are for a stern stability factor = 2.0.
L1, L2 126 nH PAUL SMITH CO. SK-138-1
4-½ Turns (yellow)
C1 Nominal 7.0 pF Adjusted for source impedance of approximately 1000 Ω, JOHANSON JMC2951

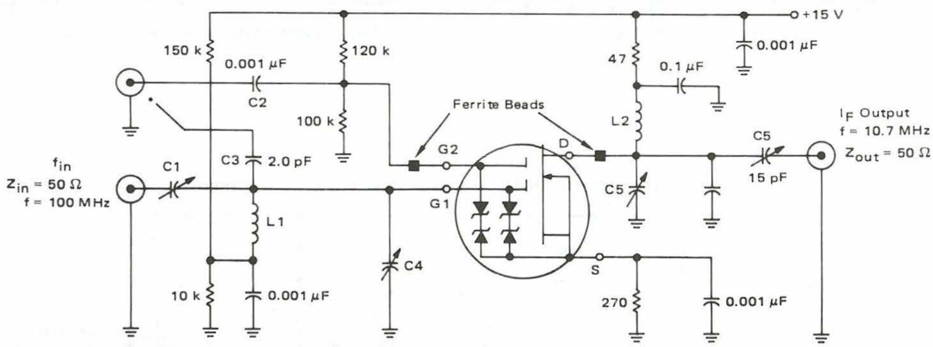
C2 Nominal 4.0 pF ARCO 402
C3 Nominal 13.73 pF ARCO 403
C4 Nominal 4.36 pF JOHANSON JMC2951
All Decoupling Capacitors are Ceramic Discs.

FIGURE 12 – CONVERSION GAIN



6

FIGURE 13 – CONVERSION GAIN TEST CIRCUIT



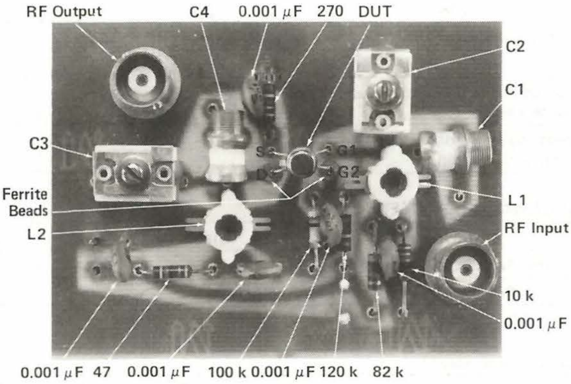
L1 126 nH PAUL SMITH CO. SK-138-1
4-½ Turns (yellow)
L2 2.73 μH High Unloaded Q
C1 JOHANSON JMC2951
C4,C5,C6 ARCO 402

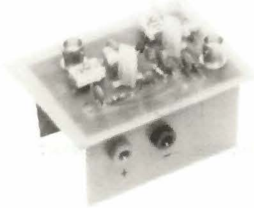
*For G1 injection, C2 is changed to bypass G2 to ground and C3 is added to connect G1 to the injection input.

PRINTED CIRCUIT BOARD LAYOUT INFORMATION

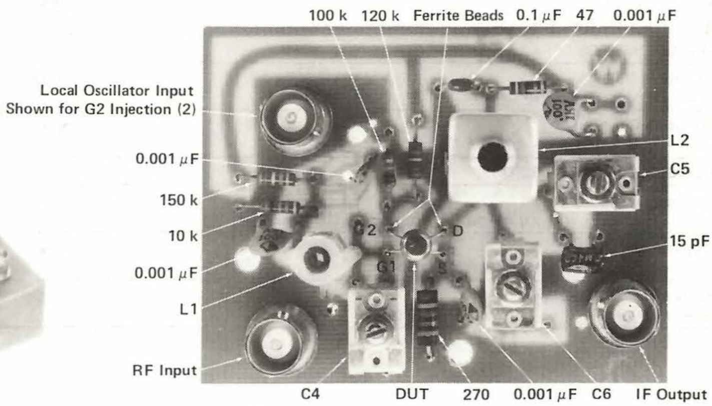
FIGURE 14 – TEST FIXTURES

105 MHz POWER GAIN AND NOISE
FIGURE TEST CIRCUIT





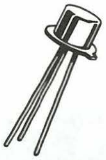
100 MHz to 10.7 MHz CONVERSION
GAIN TEST CIRCUIT



Notes:
1. C1 is on the bottom side of the board.
2. For G1 Injection, C2 is changed to bypass G2 to ground and C3 is added to connect G1 to the injection input. See Figure 13.

MFE823

CASE 22-03, STYLE 11
TO-18 (TO-206AA)



MOSFET

P-CHANNEL — ENHANCEMENT

Refer to 2N4352 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	±10	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 1.71	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +175	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	584	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	250	°C/W

6

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage ($I_D = -10\ \mu Adc$, $V_{GS} = 0$ Vdc)	$V_{(BR)DSX}$	−25	—	Vdc
Zero-Gate-Voltage Drain Current ($V_{DS} = -10$ Vdc, $V_{GS} = 0$)	I_{DSS}	—	−20	nAdc
Gate Reverse Current ($V_{GS} = -10$ Vdc, $V_{DS} = 0$)	I_{GSS}	—	1.0	pAdc
ON CHARACTERISTICS				
Gate Threshold Voltage ($V_{DS} = -10$ Vdc, $I_D = -10\ \mu Adc$)	$V_{GS(Th)}$	−2.0	−6.0	Vdc
On-State Drain Current ($V_{DS} = -10$ Vdc, $V_{GS} = -10$ Vdc)	$I_{D(on)}$	−3.0	—	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance ($V_{DS} = -10$ Vdc, $I_D = -2.0$ mAdc, f = 1.0 kHz)	$\lvert y_{fs} \rvert$	1000	—	μmhos
Input Capacitance ($V_{DS} = -10$ Vdc, $V_{GS} = -10$ Vdc, f = 1.0 MHz)	C_{iss}	—	6.0	pF
Reverse Transfer Capacitance ($V_{DS} = -10$ Vdc, $V_{GS} = -10$ Vdc, f = 1.0 MHz)	C_{rss}	—	1.5	pF

MFE825

CASE 22-03, STYLE 2
TO-18 (TO-206AA)

MOSFET

N-CHANNEL — DEPLETION

Refer to 2N3796 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	20	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Drain Current	I_D	25	mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	200 1.6	mW mW/°C
Junction Temperature Range	T_J	150	°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage ($I_D = 1.0\ \mu A$, $V_{GS} = -8.0$ V)	$V_{(BR)DSX}$	20	—	Vdc
Gate Reverse Current ($V_{GS} = -10$ V, $V_{DS} = 0$ V)	I_{GSS}	—	−1.0	pA
Gate Source Voltage ($I_D = 1.0\ \mu A$, $V_{DS} = 2.0$ V)	V_{GS}	0	−2.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current ($V_{DS} = 10$ V, $V_{GS} = 0$)	I_{DSS}	1.0	25	mA
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance ($V_{DS} = 10$ V, $V_{GS} = 0$, f = 1.0 kHz)	$\lvert y_{fs} \rvert$	500	—	μmhos

MFE910
MPF910

MFE910
CASE 79-02, STYLE 6
TO-39 (TO-205AD)

MPE910
CASE 29-03, STYLE 22
(TO-226AE)

TMOS
SWITCHING

N-CHANNEL — ENHANCEMENT

Refer to 2N6659 for additional graphs.

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	60	Vdc
Gate-Source Voltage	V_{GS}	±15	Vdc
Drain Current — Continuous(1) Pulsed(2)	I_D I_{DM}	0.5 1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C MPF910	P_D	1.0 8.0	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C MFE910	P_D	6.25 50	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

(1) The Power Dissipation of the package may result in a lower continuous drain current.
(2) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = 40 V, V_{GS} = 0)	I_{DSS}	—	0.1	10	μAdc
Gate Reverse Current (V_{GS} = 10 V, V_{DS} = 0)	I_{GSS}	—	0.01	10	nAdc
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 100 μA)	$V_{(BR)DSS}$	60	90	—	Vdc
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)	$V_{GS(th)}$	0.3	1.5	2.5	Vdc
Drain-Source On-Voltage (V_{GS} = 10 V, I_D = 500 mA)	$V_{DS(on)}$	—	—	2.5	Vdc
On-State Drain Current (V_{DS} = 25 V, V_{GS} = 10 V)	$I_{D(on)}$	500	—	—	mA
Forward Transconductance (V_{DS} = 15 V, I_D = 500 mA)	g_{fs}	100	—	—	mmhos

FIGURE 1 — $V_{GS(th)}$ NORMALIZED versus TEMPERATURE

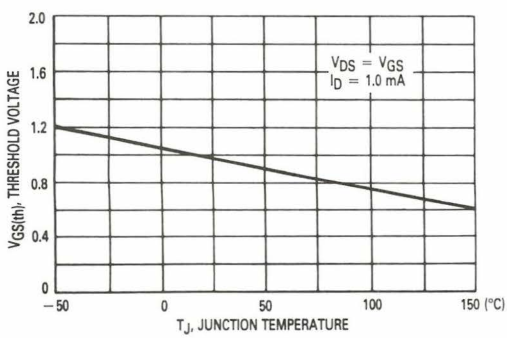


FIGURE 2 — ON-REGION CHARACTERISTICS

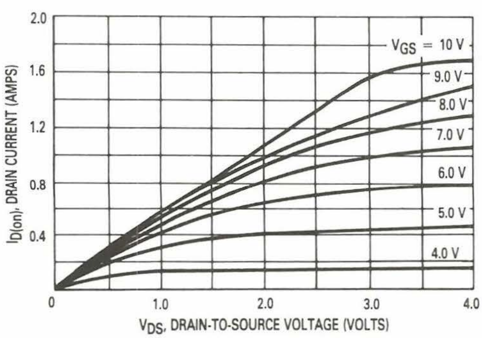


FIGURE 3 — OUTPUT CHARACTERISTICS

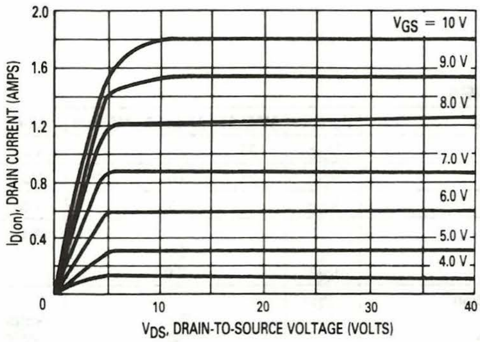
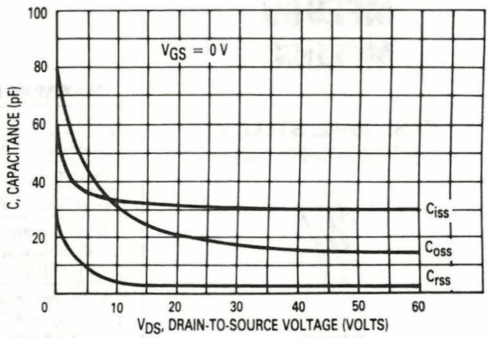


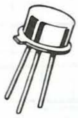
FIGURE 4 — CAPACITANCE versus DRAIN-TO-SOURCE VOLTAGE



6

MFE930
MFE960
MFE990

CASE 79-02, STYLE 6
TO-39 (TO-205AD)



TMOS
SWITCHING

N-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	MFE930	MFE960	MFE990	Unit
Drain-Source Voltage	V_{DS}	35	60	90	Vdc
Drain-Gate Voltage	V_{DG}	35	60	90	Vdc
Gate-Source Voltage	V_{GS}		±30		Vdc
Drain Current Continuous(1) Pulsed(2)	 I_D I_{DM}		 2.0 3.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D		 6.25 50		 Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−55 to 150		°C

(1) The Power Dissipation of the package may result in a lower continuous drain current.
(2) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 10 μA)	 MFE930 MFE960 MFE990	$V_{(BR)DSX}$	 35 60 90	 — — —	 — — —	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)		I_{GSS}	—	—	50	nAdc
ON CHARACTERISTICS*						
Zero-Gate-Voltage Drain Current (V_{DS} = Maximum Rating, V_{GS} = 0)		I_{DSS}	—	—	10	μAdc
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)		$V_{GS(Th)}$	1.0	—	3.5	Vdc
Drain-Source On-Voltage (V_{GS} = 10 V) (I_D = 0.5 A)	 MFE930 MFE960 MFE990	$V_{DS(on)}$	 — — —	 0.4 0.6 0.6	 0.7 0.8 1.2	Vdc
(I_D = 1.0 A)	MFE930 MFE960 MFE990		— — —	0.9 1.2 1.2	1.4 1.7 2.4	
(I_D = 2.0 A)	MFE930 MFE960 MFE990		— — —	2.2 2.8 2.8	3.0 3.5 4.8	
Static Drain-Source On Resistance (V_{GS} = 10 Vdc, I_D = 1.0 Adc)	 MFE930 MFE960 MFE990	$r_{DS(on)}$	 — — —	 0.9 1.2 1.2	 1.4 1.7 2.0	Ohms
On-State Drain Current (V_{DS} = 25 V, V_{GS} = 10 V)		$I_{D(on)}$	1.0	2.0	—	Amps
SMALL-SIGNAL CHARACTERISTICS						
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	60	70	pF
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	13	18	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{oss}	—	49	60	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Forward Transconductance (V_{DS} = 25 V, I_D = 0.5 A)	g_{fs}	200	380	—	mmhos
SWITCHING CHARACTERISTICS*					
Turn-On Time (See Figure 1)	t_{on}	—	7.0	15	ns
Turn-Off Time (See Figure 1)	t_{off}	—	7.0	15	ns

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

RESISTIVE SWITCHING

FIGURE 1 — SWITCHING TEST CIRCUIT

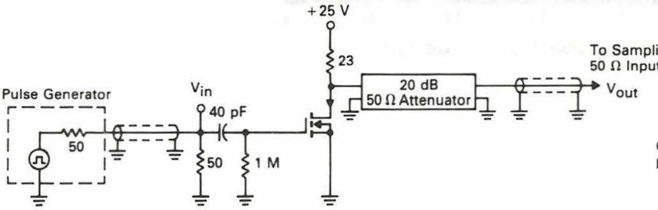


FIGURE 2 — SWITCHING WAVEFORMS

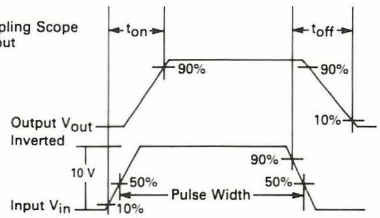


FIGURE 3 — ON VOLTAGE versus TEMPERATURE

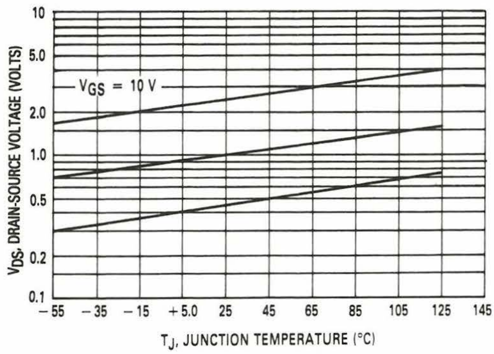


FIGURE 4 — CAPACITANCE VARIATION

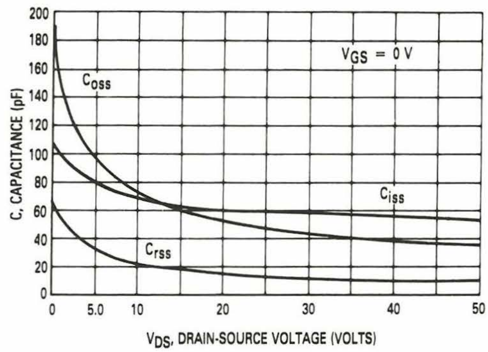


FIGURE 5 — TRANSFER CHARACTERISTIC

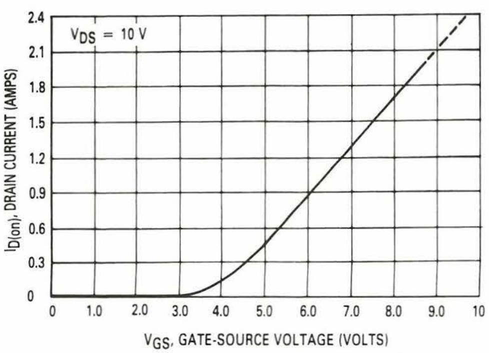
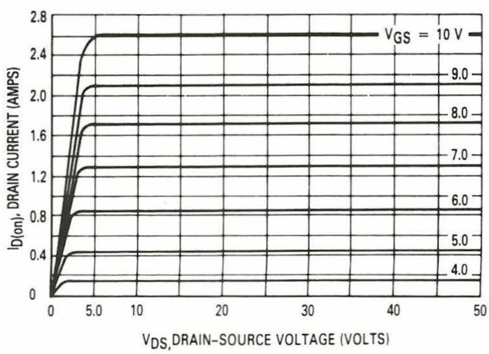
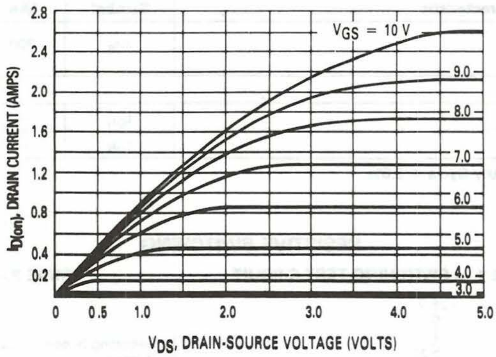


FIGURE 6 — OUTPUT CHARACTERISTIC



6

FIGURE 7 — SATURATION CHARACTERISTIC



6

MFE2000
MFE2001

CASE 20-03, STYLE 1
TO-72 (TO-206AF)

JFET
VHF/UHF AMPLIFIER

N-CHANNEL — DEPLETION

Refer to 2N4416 for graphs.

MAXIMUM RATINGS

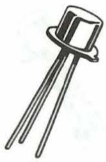
Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	−25	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = −1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	−25	—	—	Vdc
Gate Reverse Current (V_{GS} = −20 Vdc, V_{DS} = 0) (V_{GS} = −20 Vdc, V_{DS} = 0, T_A = 150°C)		I_{GSS}	 — —	 — —	 −100 −200	 pAdc nAdc
Gate Source Cutoff Voltage (I_D = 0.5 mAdc, V_{DS} = 15 Vdc)	 MFE2000 MFE2001	$V_{GS(off)}$	 −0.5 −2.0	 — —	 −4.0 −6.0	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	 MFE2000 MFE2001	I_{DSS}	 4.0 8.0	 — —	 10 20	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	 MFE2000 MFE2001	$\|y_{fs}\|$	 2500 4000	 — —	 6000 8000	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	 MFE2000 MFE2001	$\|y_{os}\|$	 — —	 — —	 50 75	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	—	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	—	1.0	pF
Output Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{oss}	—	—	2.0	pF
FUNCTIONAL CHARACTERISTICS						
Noise Figure (V_{DS} = 15 Vdc, I_D = 4.0 mAdc, f = 100 MHz, R_G ≈ 1.0 k ohm) (V_{DS} = 15 Vdc, I_D = 4.0 mAdc, f = 400 MHz, R_G ≈ 1.0 k ohm)		NF	 — —	 1.6 3.3	 2.0 4.0	dB
Common Source Power Gain (V_{DS} = 15 Vdc, I_D = 4.0 mAdc, f = 100 MHz) (V_{DS} = 15 Vdc, I_D = 4.0 mAdc, f = 400 MHz)		G_{ps}	 18 10	 23 14	 — —	dB

MFE2004
MFE2005
MFE2006

CASE 22-03, STYLE 4
TO-18 (TO-206AA)



JFET
CHOPPER

N-CHANNEL — DEPLETION

Refer to 2N4091 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10	Watts mW/°C
Junction Temperature Range	T_J	−65 to +175	°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0) (V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 150°C)		I_{GSS}	 — —	 0.2 0.4	 nAdc μAdc
Drain Cutoff Current (V_{DS} = 20 Vdc, V_{GS} = 12 Vdc) (V_{DS} = 20 Vdc, V_{GS} = 12 Vdc, T_A = 150°C)		$I_{D(off)}$	 — —	 0.2 0.4	 nAdc μAdc
Gate Source Voltage (V_{DS} = 20 Vdc, I_D = 50 μAdc)	 MFE2004 MFE2005 MFE2006	V_{GS}	 1.0 2.0 5.0	 6.0 8.0 10	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current* (V_{DS} = 20 Vdc, V_{GS} = 0)	 MFE2004 MFE2005 MFE2006	I_{DSS}*	 8.0 15 30	 — — —	mAdc
Gate-Source Forward Voltage (I_G = 1.0 mAdc, V_{DS} = 0)		$V_{GS(f)}$	—	1.0	Vdc
Drain-Source On-Voltage (I_D = 3.0 mAdc, V_{GS} = 0) (I_D = 6.0 mAdc, V_{GS} = 0) (I_D = 10 mAdc, V_{GS} = 0)	 MFE2004 MFE2005 MFE2006	$V_{DS(on)}$	 — — —	 0.4 0.4 0.4	Vdc
Static Drain-Source On Resistance (I_D = 1.0 mAdc, V_{GS} = 0)	 MFE2004 MFE2005 MFE2006	$r_{DS(on)}$	 — — —	 80 50 30	Ohms
SMALL-SIGNAL CHARACTERISTICS					
Static Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	 MFE2004 MFE2005 MFE2006	$r_{ds(on)}$	 — — —	 80 50 30	Ohms
Input Capacitance (V_{DS} = 0, V_{GS} = −12 Vdc, f = 1.0 MHz)		C_{iss}	—	16	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Reverse Transfer Capacitance		C_{rss}			pF
(V_{DS} = 0, V_{GS} = 6.0 Vdc, f = 1.0 MHz)	MFE2004		—	5.0	
(V_{DS} = 0, V_{GS} = 8.0 Vdc, f = 1.0 MHz)	MFE2005		—	5.0	
(V_{DS} = 0, V_{GS} = 12 Vdc, f = 1.0 MHz)	MFE2006		—	5.0	
SWITCHING CHARACTERISTICS					
Turn-On Delay Time		$t_{d(on)}$			ns
(V_{DD} = 3.0 Vdc, I_D = 3.0 mAdc, V_{GS} = 0)	MFE2004		—	20	
(V_{DD} = 3.0 Vdc, I_D = 6.0 mAdc, V_{GS} = 0)	MFE2005		—	15	
(V_{DD} = 3.0 Vdc, I_D = 10 mAdc, V_{GS} = 0)	MFE2006		—	10	
Rise Time		t_r			ns
(V_{DD} = 3.0 Vdc, I_D = 3.0 mAdc, V_{GS} = 0)	MFE2004		—	40	
(V_{DD} = 3.0 Vdc, I_D = 6.0 mAdc, V_{GS} = 0)	MFE2005		—	20	
(V_{DD} = 3.0 Vdc, I_D = 10 mAdc, V_{GS} = 0)	MFE2006		—	10	
Turn-Off Time		t_{off}			ns
(V_{DD} = 3.0 Vdc, I_D = 3.0 mAdc, $V_{GS(off)}$ = 6.0 Vdc)	MFE2004		—	80	
(V_{DD} = 3.0 Vdc, I_D = 6.0 mAdc, $V_{GS(off)}$ = 8.0 Vdc)	MFE2005		—	60	
(V_{DD} = 3.0 Vdc, I_D = 10 mAdc, $V_{GS(off)}$ = 12 Vdc)	MFE2006		—	40	

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 3.0%.

6

MFE2010
MFE2011
MFE2012

CASE 22-03, STYLE 4
TO-18 (TO-206AA)

JFET
CHOPPER

N-CHANNEL — DEPLETION

Refer to J107 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Forward Gate Current	I_{GF}	50	mAdc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.8 10	Watt mW/°C
Junction Temperature Range	T_J	−65 to +175	°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = 10\ \mu Adc$, $V_{DS} = 0$)		$V_{(BR)GSS}$	25	—	Vdc
Gate Reverse Current ($V_{GS} = 15$ Vdc, $V_{DS} = 0$) ($V_{GS} = 15$ Vdc, $V_{DS} = 0$, $T_A = 150°C$)		I_{GSS}	 — —	 3.0 6.0	 nAdc μAdc
Drain Cutoff Current ($V_{DS} = 15$ Vdc, $V_{GS} = 12$ Vdc) ($V_{DS} = 15$ Vdc, $V_{GS} = 12$ Vdc, $T_A = 150°C$)		$I_{D(off)}$	 — —	 3.0 6.0	 nAdc μAdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current* ($V_{DS} = 20$ Vdc, $V_{GS} = 0$)	 MFE2010 MFE2011 MFE2012	I_{DSS}*	 15 40 100	 — — —	mAdc
Gate-Source Forward Voltage ($I_G = 1.0$ mAdc, $V_{DS} = 0$)		$V_{GS(f)}$	—	1.0	Vdc
Gate-Source Voltage ($V_{DS} = 15$ Vdc, $I_D = 1.0\ \mu Adc$)	 MFE2010 MFE2011 MFE2012	V_{GS}	 0.5 1.0 3.0	 10 10 10	Vdc
Drain-Source On-Voltage ($I_D = 8.0$ mAdc, $V_{GS} = 0$) ($I_D = 15$ mAdc, $V_{GS} = 0$) ($I_D = 30$ mAdc, $V_{GS} = 0$)	 MFE2010 MFE2011 MFE2012	$V_{DS(on)}$	 — — —	 0.75 0.75 0.75	Vdc
Static Drain-Source On Resistance ($I_D = 1.0$ mAdc, $V_{GS} = 0$)	 MFE2010 MFE2011 MFE2012	$r_{DS(on)}$	 — — —	 25 15 10	Ohms
SMALL-SIGNAL CHARACTERISTICS					
Static Drain-Source "ON" Resistance ($V_{GS} = 0$, $I_D = 0$, f = 1.0 kHz)	 MFE2010 MFE2011 MFE2012	$r_{ds(on)}$	 — — —	 25 15 10	Ohms
Input Capacitance ($V_{DS} = 0$, $V_{GS} = 10$ Vdc, f = 1.0 MHz)		C_{iss}	—	50	pF
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = 12$ Vdc, f = 1.0 MHz)		C_{rss}	—	20	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS					
Turn-On Delay Time		$t_{d(on)}$	—	10	ns
Rise Time		t_r	—	6.0	ns
Turn-Off Delay Time		$t_{d(off)}$			ns
(V_{DD} = 15 Vdc, I_D = 8.0 mAdc)	MFE2010		—	35	
(V_{DD} = 15 Vdc, I_D = 15 mAdc)	MFE2011		—	20	
(V_{DD} = 15 Vdc, I_D = 30 mAdc)	MFE2012		—	12	
Fall Time		t_f			ns
(V_{DD} = 15 Vdc, I_D = 8.0 mAdc)	MFE2010		—	75	
(V_{DD} = 15 Vdc, I_D = 15 mAdc)	MFE2011		—	45	
(V_{DD} = 15 Vdc, I_D = 30 mAdc)	MFE2012		—	25	

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 3.0%.

6

MFE3001

CASE 20-03, STYLE 2
TO-72 (TO-206AF)

FET
LOW-POWER AUDIO

N-CHANNEL — DEPLETION

Refer to 2N3796 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	20	Vdc
Drain-Gate Voltage	V_{DG}	±20	Vdc
Drain Current	I_D	20	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Junction Temperature Range	T_J	+200	°C
Storage Temperature Range	T_{stg}	−65 to +175	°C

6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage (V_{GS} = −8.0 V, I_D = 10 μAdc)	$V_{(BR)DSX}$	20	—	Vdc
Gate Reverse Current (V_{GS} = −10 Vdc, V_{DS} = 0)	I_{GSS}	—	10	pAdc
Gate Source Cutoff Voltage (I_{DS} = 1.0 μAdc, V_{DS} = 10 Vdc)	$V_{GS(off)}$	—	−8.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V_{GS} = 0 Vdc, V_{DS} = 10 Vdc)	I_{DSS}	0.5	6.0	mAdc
On-State Drain Current (V_{GS} = 3.5 Vdc, V_{DS} = 10 Vdc)	$I_{D(on)}$	5.0	—	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{fs}\|$	700	3500	μmhos
Output Admittance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{os}\|$	—	100	μmhos
Input Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	1.5	pF

MFE3002

CASE 20-03, STYLE 7
TO-72 (TO-206AF)

MOSFET
CHOPPER

N-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	15	Vdc
Drain-Gate Voltage	V_{DG}	20	Vdc
Gate-Source Voltage	V_{GS}	±20	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	200 1.4	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V_{DS} = +10 Vdc, V_{GS} = 0) (V_{DS} = +10 Vdc, V_{GS} = 0, T_C = 125°C)	I_{DSS}	 — —	 10 100	nAdc
Gate Reverse Current (V_{GS} = ±10 Vdc, V_{DS} = 0)	I_{GSS}	—	±100	pAdc
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 10 μAdc)	$V_{(BR)DS}$	15	—	Vdc
ON CHARACTERISTICS				
Gate Threshold Voltage (V_{DS} = +10 Vdc, I_D = 10 μAdc)	$V_{GS(TH)}$	—	3.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Input Capacitance (V_{DS} = +10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	1.0	pF
Drain-Substrate Capacitance ($V_{D(SUB)}$ = +10 Vdc, f = 1.0 MHz)	$C_{d(sub)}$	—	4.0	pF
Static Drain-Source On Resistance (V_{GS} = +10 Vdc, I_D = 0, f = 1.0 kHz)	$r_{ds(on)}$	—	100	Ohms

MFE3003

CASE 20-03, STYLE 5
TO-72 (TO-206AF)

MOSFET
CHOPPER

P-CHANNEL — ENHANCEMENT

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	−15	Vdc
Drain-Gate Voltage	V_{DG}	±20	Vdc
Gate-Source Voltage	V_{GS}	±20	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	200 1.33	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage ($V_{GS} = 0$, $I_D = -10\ \mu Adc$)	$V_{(BR)DSX}$	−15	—	Vdc
Zero-Gate-Voltage Drain Current ($V_{DS} = -10$ Vdc, $V_{GS} = 0$) ($V_{DS} = -10$ Vdc, $V_{GS} = 0$, $T_C = 125°C$)	I_{DSS}	 — —	 −10 −100	nAdc
Gate Reverse Current ($V_{GS} = \pm 10$ Vdc, $V_{DS} = 0$)	I_{GSS}	—	±100	pAdc
ON CHARACTERISTICS				
Gate Threshold Voltage ($V_{DS} = -10$ Vdc, $I_D = -10\ \mu Adc$)	$V_{GS(Th)}$	—	−4.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Drain-Source Resistance ($V_{GS} = -10$ Vdc, $I_D = 0$, f = 1.0 kHz)	$r_{ds(on)}$	—	200	Ohms
Input Capacitance ($V_{DS} = -10$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)	C_{iss}	—	4.0	pF
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = 0$, f = 1.0 MHz)	C_{rss}	—	1.0	pF
Drain-Substrate Capacitance ($V_{D(SUB)} = -10$ Vdc, f = 1.0 MHz)	$C_{d(sub)}$	—	2.0	pF

MFE3004
MFE3005

CASE 20-03, STYLE 7
TO-72 (TO-206AF)

MOSFET
VHF/UHF AMPLIFIER

N-CHANNEL — DEPLETION

6

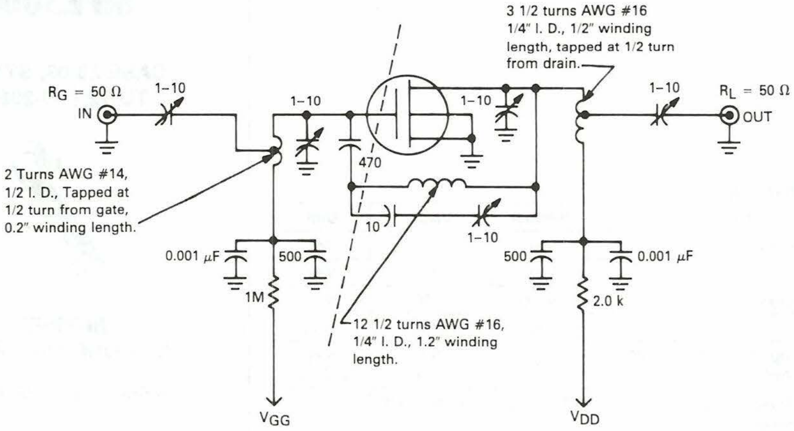
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	20	Vdc
Drain-Gate Voltage	V_{DG}	20	Vdc
Gate-Source Voltage	V_{GS}	±20	Vdc
Drain Current	I_D	10	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	200 1.33	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage (V_{GS} = −5.0 Vdc, I_D = 10 μAdc)	$V_{(BR)DSX}$	20	—	Vdc
Gate Reverse Current (V_{GS} = ±15 Vdc, V_{DS} = 0)	I_{GSS}	—	±50	pAdc
Gate Source Cutoff Voltage (I_D = 10 μAdc, V_{DS} = 15 Vdc)	$V_{GS(off)}$	—	−5.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	2.0	10	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 15 Vdc, I_D = 2.0 mAdc, f = 1.0 kHz)	$\|y_{fs}\|$	2000	—	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	4.5	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	0.4	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure (V_{DS} = 15 Vdc, I_D = 2.0 mAdc, R_S ≈ 1.8 k ohms, f = 200 MHz) (Figure 1) MFE3004 (V_{DS} = 15 Vdc, I_D = 2.0 mAdc, R_S ≈ 650 ohms, f = 400 MHz) (Figure 2) MFE3005	NF	 — —	 4.5 4.5	dB
Common Source Power Gain (V_{DS} = 15 Vdc, I_D = 2.0 mAdc, R_S ≈ 1.8 k ohms, f = 200 MHz) (Figure 1) MFE3004 (V_{DS} = 15 Vdc, I_D = 2.0 mAdc, R_S ≈ 650 ohms, f = 400 MHz) (Figure 2) MFE3005	G_{ps}	 16 10	 — —	dB

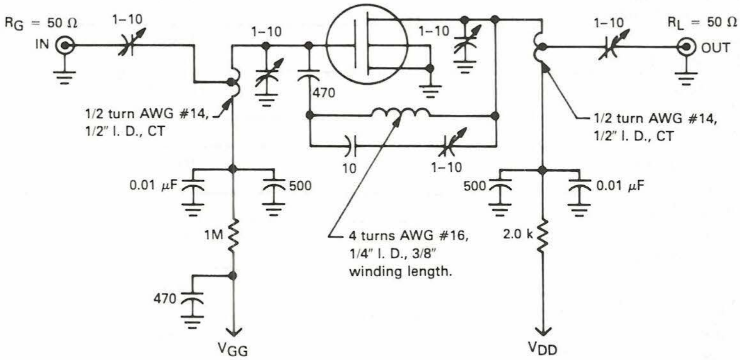
FIGURE 1 — 200 MHz TEST CIRCUIT — NEUTRALIZED



Unless otherwise specified: Capacitance values in pF

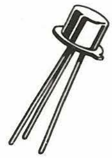
6

FIGURE 2 — 400 MHz TEST CIRCUIT — NEUTRALIZED



MFE9200

CASE 22-03, STYLE 12
TO-18 (TO-206AA)



TMOS
SWITCHING

N-CHANNEL — ENHANCEMENT

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	200	Vdc
Gate-Source Voltage	V_{GS}	±20	Vdc
Drain Current Continuous (1) Pulsed (2)	 I_D I_{DM}	 400 800	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 14.4	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 10 μA)	$V_{(BR)DSX}$	200	—	—	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)	I_{GSS}	—	0.01	50	nAdc
ON CHARACTERISTICS*					
Zero-Gate-Voltage Drain Current (V_{DS} = 200 V, V_{GS} = 0)	I_{DSS}	—	0.1	10	μAdc
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)	$V_{GS(Th)}$	1.0	—	4.0	Vdc
Drain-Source On-Voltage (V_{GS} = 10 V) (I_D = 100 mA) (I_D = 250 mA) (I_D = 500 mA)	$V_{DS(on)}$	 — — —	 0.45 1.20 3.0	 0.6 1.60 —	Vdc
Static Drain-Source On Resistance (V_{GS} = 10 Vdc) (I_D = 100 mA) (I_D = 250 mA) (I_D = 500 mA)	$r_{DS(on)}$	 — — —	 4.5 4.8 6.0	 6.0 6.4 —	Ohms
On-State Drain Current (V_{DS} = 25 V, V_{GS} = 10 V)	$I_{D(on)}$	400	700	—	mA
SMALL-SIGNAL CHARACTERISTICS					
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	72	90	pF
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	2.8	3.5	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	15	20	pF
Forward Transconductance (V_{DS} = 25 V, I_D = 250 mA)	g_{fs}	200	400	—	mmhos
SWITCHING CHARACTERISTICS					
Turn-On Time See Figure 1	t_{on}	—	6.0	15	ns
Turn-Off Time See Figure 1	t_{off}	—	6.0	15	ns

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

RESISTIVE SWITCHING

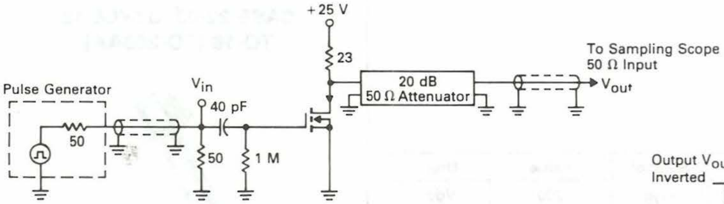


FIGURE 1 — SWITCHING TEST CIRCUIT

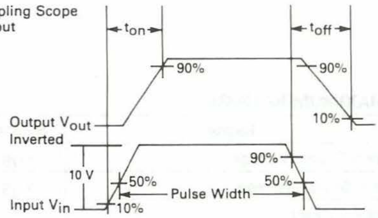


FIGURE 2 — SWITCHING WAVEFORMS

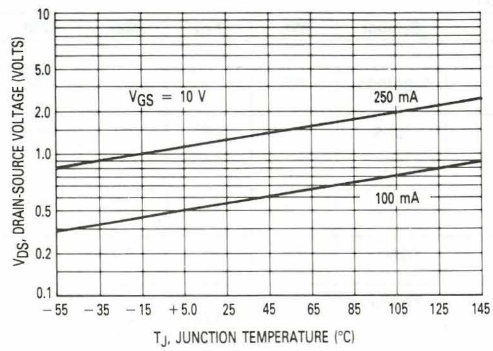


FIGURE 3 — ON VOLTAGE versus TEMPERATURE

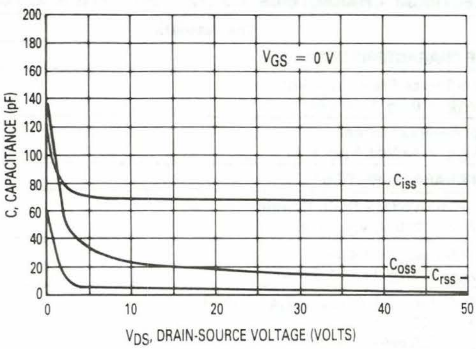


FIGURE 4 — CAPACITANCE VARIATION

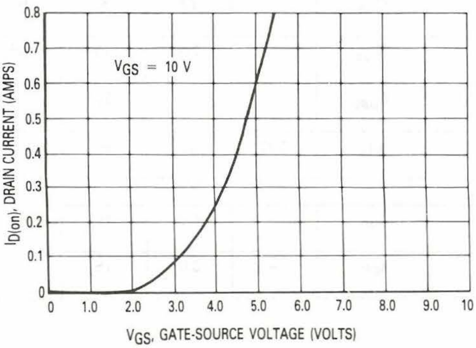


FIGURE 5 — TRANSFER CHARACTERISTIC

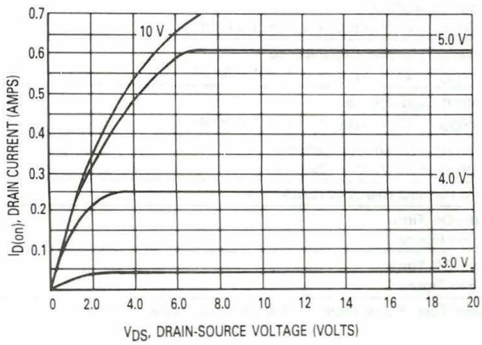
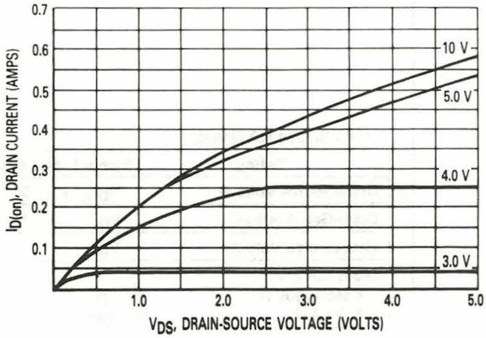


FIGURE 6 — OUTPUT CHARACTERISTIC

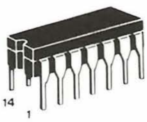
FIGURE 7 — SATURATION CHARACTERISTIC



6

MFQ930C
MFQ960C
MFQ990C

CASE 632-02, STYLE 1
TO-116



QUAD
DUAL-IN-LINE
TMOS

N-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	MFQ930C	MFQ960C	MFQ990C	Unit
Drain-Source Voltage	V_{DS}	35	60	90	Vdc
Drain-Gate Voltage	V_{DG}	35	60	90	Vdc
Gate-Source Voltage	V_{GS}		±30		Vdc
Drain Current Continuous (1) Pulsed (2)	 I_D I_{DM}		 2.0 3.0		Adc
			Each Transistor	Total Device	
Total Device Dissipation @ T_A = 25°C Derate Above 25°C	P_D		0.5 17.0	2.0 66.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−55 to +150		°C

Refer to MFE930 for graphs.

6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 10 μA)	MFQ930C MFQ960C MFQ990C	$V_{(BR)DSX}$	35 60 90	— — —	— — —	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)		I_{GSS}	—	—	50	nAdc
ON CHARACTERISTICS*						
Zero-Gate-Voltage Drain Current (V_{DS} = Maximum Rating, V_{GS} = 0)		I_{DSS}	—	—	10	μAdc
Gate Threshold Voltage (I_D = 1.0 mA, V_{DS} = V_{GS})		$V_{GS(Th)}$	1.0	—	3.5	Vdc
Drain-Source On-Voltage (V_{GS} = 10 V) (I_D = 0.5 A)	MFQ930C MFQ960C MFQ990C	$V_{DS(on)}$	— — —	0.4 0.6 0.6	0.7 0.8 1.0	Vdc
(I_D = 1.0 A)	MFQ930C MFQ960C MFQ990C		— — —	0.9 1.2 1.2	1.4 1.7 2.0	
(I_D = 2.0 A)	MFQ930C MFQ960C MFQ990C		— — —	2.2 2.8 2.8	3.0 3.5 4.0	
Static Drain-Source On Resistance (V_{GS} = 10 Vdc, I_D = 1.0 Adc)	MFQ930C MFQ960C MFQ990C	$r_{DS(on)}$	— — —	0.9 1.2 1.2	1.4 1.7 2.0	Ohms
On-State Drain Current (V_{DS} = 25 V, V_{GS} = 10 V)		$I_{D(on)}$	1.0	2.0	—	Amps
SMALL-SIGNAL CHARACTERISTICS						
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	60	70	pF
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	13	18	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{oss}	—	49	60	pF
Forward Transconductance (V_{DS} = 25 V, I_D = 0.5 A)		g_{fs}	200	380	—	mmhos
SWITCHING CHARACTERISTICS						
Turn-On Time		t_{on}	—	7.0	15	ns
Turn-Off Time		t_{off}	—	7.0	15	ns

MPF102

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
VHF AMPLIFIER

N-CHANNEL — DEPLETION

Refer to 2N4416 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	−25	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	200 2	mW mW/°C
Junction Temperature Range	T_J	125	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = -10\ \mu Adc$, $V_{DS} = 0$)	$V_{(BR)GSS}$	−25	—	Vdc
Gate Reverse Current ($V_{GS} = -15$ Vdc, $V_{DS} = 0$) ($V_{GS} = -15$ Vdc, $V_{DS} = 0$, $T_A = 100°C$)	I_{GSS}	 — —	 −2.0 −2.0	 nAdc μAdc
Gate Source Cutoff Voltage ($V_{DS} = 15$ Vdc, $I_D = 2.0$ nAdc)	$V_{GS(off)}$	—	−8.0	Vdc
Gate Source Voltage ($V_{DS} = 15$ Vdc, $I_D = 0.2$ mAdc)	V_{GS}	−0.5	−7.5	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current* ($V_{DS} = 15$ Vdc, $V_{GS} = 0$ Vdc)	I_{DSS}	2.0	20	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance* ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz) ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 100 MHz)	$\lvert y_{fs} \rvert$	 2000 1600	 7500 —	μmhos
Input Admittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 100 MHz)	$Re(y_{is})$	—	800	μmhos
Output Conductance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 100 MHz)	$Re(y_{os})$	—	200	μmhos
Input Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)	C_{iss}	—	7.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)	C_{rss}	—	3.0	pF

*Pulse Test: Pulse Width ≤ 630 ms; Duty Cycle ≤ 10%.

6

MPF108

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
VHF AMPLIFIER
N-CHANNEL — DEPLETION

Refer to 2N4416 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	−25	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Junction Temperature Range	T_J	−65 to +135	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	−25	—	Vdc
Gate Reverse Current (V_{GS} = −15 Vdc, V_{DS} = 0) (V_{GS} = −15 Vdc, V_{DS} = 0, T_A = 100°C)	I_{GSS}	— —	1.0 −1.0	nAdc μAdc
Gate-Source Cutoff Voltage* (V_{DS} = 15 Vdc, I_D = 10 μAdc)	$V_{GS(off)}$*	0.5	8.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}*	1.5	24	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$\|y_{fs}\|$	1600	—	μmhos
Forward Transadmittance* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	y_{fs}*	2000	7500	μmhos
Input Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$Re(y_{is})$	—	800	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{os}\|$	—	75	μmhos
Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$Re(y_{os})$	—	200	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	6.5	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	2.5	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 Megohm, f = 1.0 kHz) (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 k ohm, f = 100 MHz)	NF	 — —	 2.5 3.0	dB

*To characterize these devices to narrower limits, regarding I_{DSS}, $V_{GS(off)}$ and y_{fs}, the entire production lot is tested and divided into color-coded groups, with each color dot representing a relatively small range compared with the total min-max limit of the whole distribution. The color codes and their associated limits are given in the following table.

When packaged for shipment, the colors are randomly selected and no specific color distribution is implied or guaranteed.

Color	I_{DS}	$V_{GS(off)}$	Y_{fs}
Orange	1.5 mAdc, Min, 3.0 mAdc Max	0.5 Vdc Min, 5.0 Vdc Max	2000 to 6500 μmhos
Yellow	2.5 mAdc Min, 5.0 mAdc Max	0.5 Vdc Min, 5.0 Vdc Max	2000 to 6500 μmhos
Green	4.0 mAdc Min, 8.0 mAdc Max	1.0 Vdc Min, 7.0 Vdc Max	2500 to 7000 μmhos
Blue	7.0 mAdc Min, 14 mAdc Max	1.0 Vdc Min, 7.0 Vdc Max	2500 to 7000 μmhos
Violet	12 mAdc Min, 24 mAdc Max	2.0 Vdc Min, 8.0 Vdc Max	3000 to 7500 μmhos

MPF111

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
GENERAL PURPOSE

N-CHANNEL — DEPLETION

Refer to 2N4220 for graphs.

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	20	Vdc
Drain-Gate Voltage	V_{DG}	20	Vdc
Gate-Source Voltage	V_{GS}	−20	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	310 2.0	mW mW/°C
Junction Temperature Range	T_J	125	°C
Storage Channel Temperature Range	T_{stg}	−65 to +135	°C

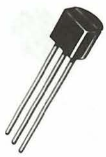
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = -10\ \mu Adc$, $V_{DS} = 0$)	$V_{(BR)GSS}$	−20	—	—	Vdc
Gate Reverse Current ($V_{GS} = -10$ Vdc, $V_{DS} = 0$)	I_{GSS}	—	0.1	100	nAdc
Gate Source Cutoff Voltage ($V_{DS} = 10$ Vdc, $I_D = 1.0\ \mu Adc$)	$V_{GS(off)}$	−0.5	—	−10	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) ($V_{DS} = 10$ Vdc, $V_{GS} = 0$)	I_{DSS}	0.5	—	20	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance(1) ($V_{DS} = 10$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)	$\|y_{fs}\|$	500	—	—	μmhos
Output Admittance(1) ($V_{DS} = 10$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)	$\|y_{os}\|$	—	20	—	μmhos
Input Capacitance ($V_{DS} = 10$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)	C_{iss}	—	4.5	—	pF
Reverse Transfer Capacitance ($V_{DS} = 10$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)	C_{rss}	—	1.5	—	pF

(1) Pulse Test: Pulse Width ≤ 630 ms; Duty Cycle ≤ 10%.

MPF112

CASE 29-02, STYLE 5
TO-92 (TO-226AA)



JFET
VHF AMPLIFIER

N-CHANNEL — DEPLETION

Refer to 2N4416 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	−25	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 2.0	mW mW/°C
Junction Temperature Range	T_J	125	°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = −10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	−25	—	—	Vdc
Gate Reverse Current (V_{GS} = −10 Vdc, V_{DS} = 0)	I_{GSS}	—	—	100	nAdc
Gate Source Cutoff Voltage (V_{DS} = 10 Vdc, I_D = 1.0 μAdc)	$V_{GS(off)}$	−0.5	—	−10	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 10 Vdc, V_{GS} = 0)	I_{DSS}	1.0	—	25	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 kHz)(1) (V_{DS} = 10 Vdc, V_{GS} = 0, f = 100 MHz)	$\lvert y_{fs} \rvert$	 1000 800	 — —	 7500 —	μmhos
Input Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	8.0	—	pF
Reverse Transfer Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	3.0	—	pF

(1) Pulse Test: Pulse Width ≤ 630 ms; Duty Cycle ≤ 10%.

MPF130,131,132
MFE130,131,132

MPF130 SERIES
CASE 317-01, STYLE 1

MFE130 SERIES
CASE 20-03, STYLE 9
TO-72 (TO-206AF)

DUAL-GATE
MOSFET
VHF AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Drain-Source Voltage	V_{DS}	25		Vdc
Drain Current	I_D	30		mAdc
		MPF130 Series	MFE130 Series	
Total Device Dissipation @ T_A = 25°C (Package Limitation) Derate above 25°C	P_D	300 2.4	300 1.71	mW mW/°C
Operating and Storage Channel Temperature Range	$T_{channel}$, T_{stg}	−65 to +150	−65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (I_D = 10 μAdc, V_S = 0, V_{G1} = −4.0 V, V_{G2} = +4.0 V)	$V_{(BR)DSX}$	25	—	—	Vdc
Gate 1-Source Breakdown Voltage (I_{G1} = ±10 μAdc, V_{G2S} = 0)	$V_{(BR)G1SO}$	±7.0	—	±20	Vdc
Gate 2-Source Breakdown Voltage (I_{G2} = ±10 μAdc, V_{G2S} = 0)	$V_{(BR)G2SO}$	±7.0	—	±20	Vdc
Gate 1 Leakage Current (V_{G1S} = ±6.0 Vdc, V_{G2S} = 0, V_{DS} = 0)	I_{G1SS}	—	—	20	nAdc
Gate 2 Leakage Current (V_{G2S} = ±6.0 Vdc, V_{G1S} = 0, V_{DS} = 0)	I_{G2SS}	—	—	20	nAdc
Gate 1 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 200 μAdc)	$V_{G1S(off)}$	—	—	−4.0	Vdc
Gate 2 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G1S} = 0, I_D = 200 μAdc)	$V_{G2S(off)}$	—	—	−4.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = 15 Vdc, V_{G1S} = 0, V_{G2S} = 4.0 Vdc)	I_{DSS}	3.0	10	30	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (Gate 1 connected to Drain) (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, f = 1.0 kHz)	$\|y_{fs}\|$	8000	—	20000	μmhos
Input Capacitance (V_{DS} = 15 Vdc V_{G2S} = 4.0 Vdc, I_D = I_{DSS}, f = 1.0 MHz)	C_{iss}	—	4.5	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc, f = 1.0 MHz)	C_{rss}	—	0.023	0.05	pF
Output Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = I_{DSS}, f = 1.0 MHz)	C_{oss}	—	2.5	4.0	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (Figure 7) (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc, Z_S is optimized for NF)	NF				dB
(f = 105 MHz) MPF/MFE130		—	2.9	5.0	
(f = 60 MHz) MPF/MFE131		—	2.5	5.0	
(f = 100 MHz) MPF/MFE131		—	3.0	5.0	

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Common Source Power Gain (Figure 7) (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc, Z_S is optimized for NF)		G_{ps}				dB
(f = 105 MHz)	MPF/MFE130		17	23	—	
(f = 60 MHz)	MPF/MFE131		20	27	—	
(f = 200 MHz)	MPF/MFE131		17	20	—	
Level of Unwanted Signal for 1.0% Cross Modulation (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc)		—	—	100	—	mV
Common-Source Conversion Power Gain (Gate 1 Injection, Figure 8) (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, Local Oscillator Voltage = 925 mVrms)		G_c				dB
(Signal Frequency = 60 MHz, Local Oscillator Frequency = 104 MHz)	MPF/MFE132		15	16.5	—	
(Signal Frequency = 200 MHz, Local Oscillator Frequency = 244 MHz)	MPF/MFE132		12	14	—	

6

COMMON-SOURCE ADMITTANCE PARAMETERS

(V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc)

FIGURE 1 – INPUT ADMITTANCE

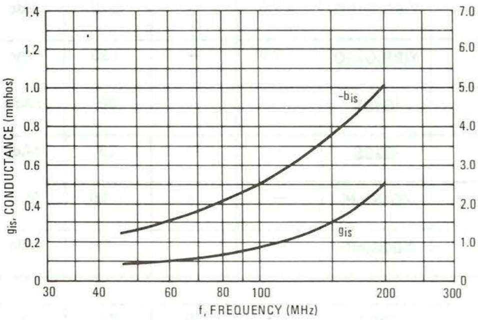


FIGURE 2 – REVERSE TRANSFER ADMITTANCE

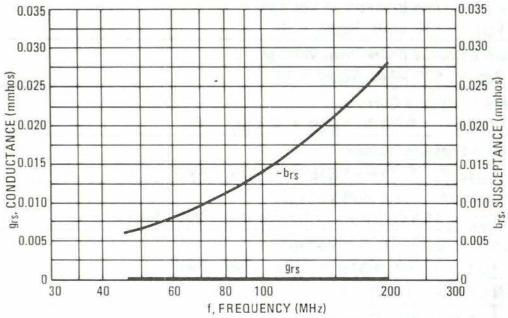


FIGURE 3 – FORWARD TRANSFER ADMITTANCE

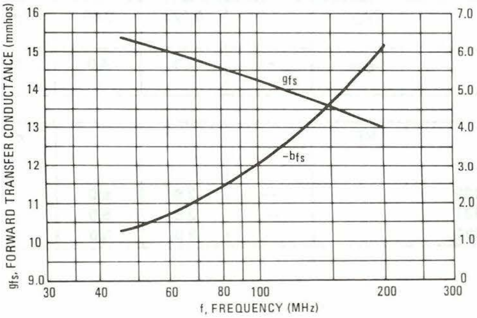


FIGURE 4 – OUTPUT ADMITTANCE

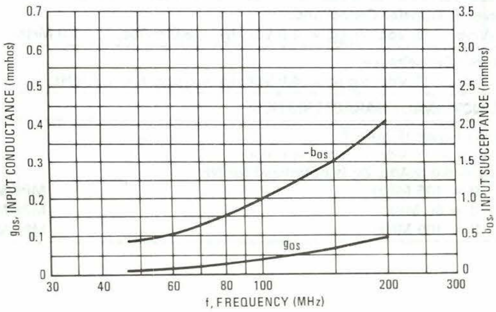


FIGURE 5 – GAIN REDUCTION

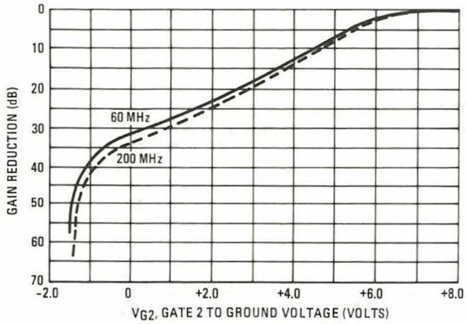


FIGURE 6 – CONVERSION POWER GAIN

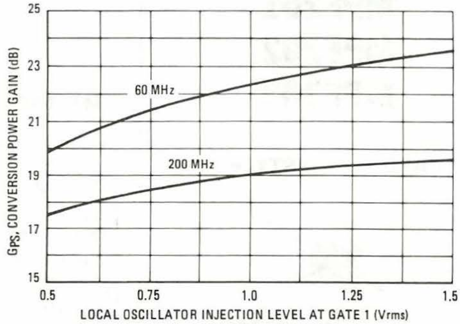
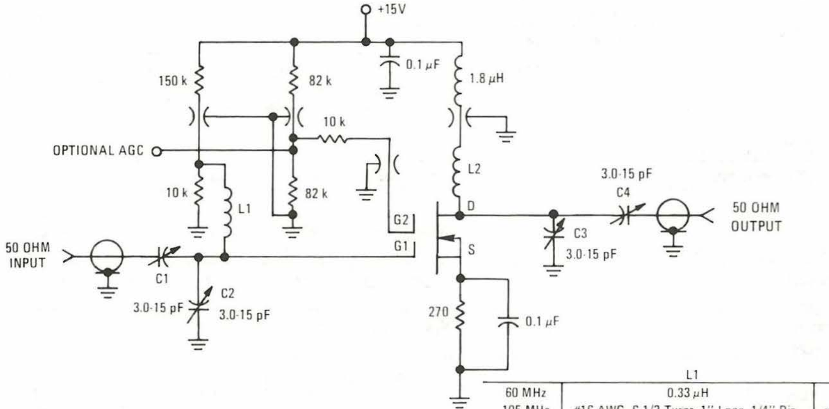


FIGURE 7 – 60, 105 AND 200 MHz POWER GAIN AND NOISE FIGURE TEST CIRCUIT

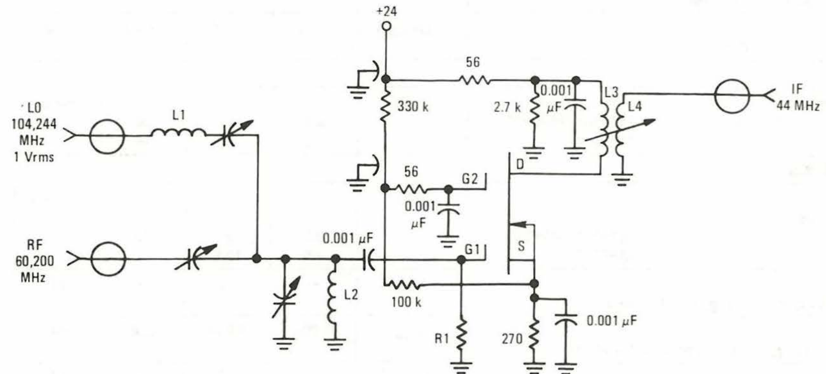


	L1	L2
60 MHz	0.33 μH	0.47 μH
105 MHz	#16 AWG, 6 1/2 Turns, 1" Long, 1/4" Dia.	#16 AWG, 5 1/4 Turns, 1" Long, 7/16" Dia.
200 MHz	#16 AWG, 3 1/2 Turns, 0.7" Long, 0.2" Dia.	#16 AWG, 4 1/2 Turns, 0.65" Long, 0.2" Dia.

All Feedthrough Capacitors 1000 pF

All Variable Capacitors JOHANSON JMC2951, 3.0-15 pF

FIGURE 8 – 60 AND 200 MHz CONVERSION GAIN TEST CIRCUIT



	R1	L1	L2	L3	L4
60 MHz	10 k	10 Turns #22 Enameled on MILLER 4500-4 Core	0.33 μH DELEVAN	15 Turns #26 Enameled on MILLER 4500-1 Core	4 Turns #26 Enameled on Same Core as L3
200 MHz	1.0 k	3 1/2 Turns #18, 1/4" Dia., 1/2" Long	2 1/2 Turns #18, 3/8" Dia., 1/2" Long	15 Turns #26 Enameled on MILLER 4500-1 Core	4 Turns #26 Enameled on Same Core as L3

All Feedthrough Capacitors 1000 pF.

All Variable Capacitors JOHANSON JMC2951, 3.0-15 pF.

6

MPF201
MPF202
MPF203

CASE 317-01, STYLE 1

DUAL-GATE MOSFET VHF AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG1} V_{DG2}	30 30	Vdc
Drain Current	I_D	50	mAdc
Gate Current	I_{G1} I_{G2}	±10 ±10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 8.0	Watt mW/°C
Lead Temperature	T_L	260	°C
Junction Temperature Range	T_J	−65 to +150	°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

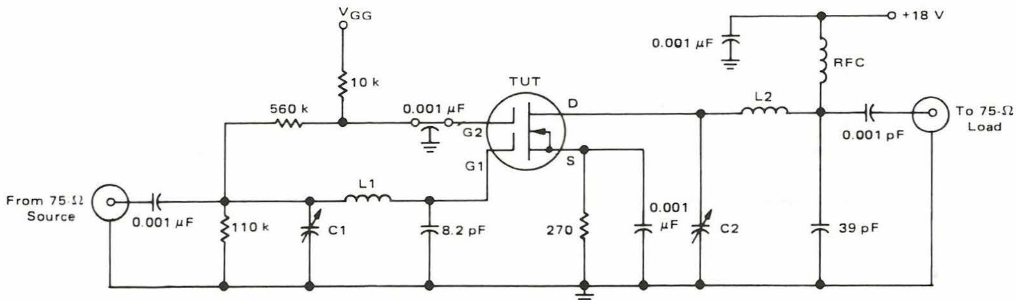
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (I_D = 10 μAdc, V_S = 0, V_{G1S} = V_{G2S} = −5.0 Vdc)	$V_{(BR)DSX}$	25	—	—	Vdc
Gate 1-Source Breakdown Voltage(1) (I_{G1} = ±10 mAdc, V_{G2S} = V_{DS} = 0)	$V_{(BR)G1SO}$	±6.0	±12	±30	Vdc
Gate 2-Source Breakdown Voltage(1) (I_{G2} = ±10 mAdc, V_{G1S} = V_{DS} = 0)	$V_{(BR)G2SO}$	±6.0	±12	±30	Vdc
Gate 1 Leakage Current (V_{G1S} = ±5.0 Vdc, V_{G2S} = V_{DS} = 0) (V_{G1S} = −5.0 Vdc, V_{G2S} = V_{DS} = 0, T_A = 150°C)	I_{G1SS}	 — —	 ±0.040 —	 ±100 −100	 nAdc μAdc
Gate 2 Leakage Current (V_{G2S} = ±5.0 Vdc, V_{G1S} = V_{DS} = 0) (V_{G2S} = −5.0 Vdc, V_{G1S} = V_{DS} = 0, T_A = 150°C)	I_{G2SS}	 — —	 ±0.050 —	 ±100 −100	 nAdc μAdc
Gate 1 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 20 μAdc)	$V_{G1S(off)}$	−0.5	−1.5	−5.0	Vdc
Gate 2 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G1S} = 0, I_D = 20 μAdc)	$V_{G2S(off)}$	−0.2	−1.4	−5.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(2) (V_{DS} = 15 Vdc, V_{G1S} = V_{G2S} = 4.0 Vdc) MPF201, MPF202 MPF203	I_{DSS}	 6.0 3.0	 13 11	 30 15	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance(3) (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, V_{G1S} = 0, f = 1.0 kHz) MPF201, MPF202 MPF203	$\|Y_{fs}\|$	 8.0 7.0	 12.8 12.5	 20 15	mmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = I_{DSS}, f = 1.0 MHz)	C_{iss}	—	3.3	—	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, f = 1.0 MHz)	C_{rss}	0.005	0.014	0.05	pF
Output Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = I_{DSS}, f = 1.0 MHz)	C_{oss}	—	1.7	—	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DD} = 18 Vdc, V_{GG} = 7.0 Vdc, f = 200 MHz) (Figure 1) MPF201 (V_{DD} = 18 Vdc, V_{GG} = 6.0 Vdc, f = 45 MHz) (Figure 3) MPF203	NF	 — —	 1.8 5.3	 5.0 6.0	dB

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Common Source Power Gain		G_{ps}				dB
(V_{DD} = 18 Vdc, V_{GG} = 7.0 Vdc, f = 200 MHz) (Figure 1)	MPF201		15	20	25	
(V_{DD} = 18 Vdc, V_{GG} = 6.0 Vdc, f = 45 MHz) (Figure 3)	MPF203		20	25	30	
(V_{DD} = 18 Vdc, f_{LO} = 245 MHz, f_{RF} = 200 MHz) (Figure 2)	MPF202	G_c(5)	15	19	25	
Bandwidth		BW				MHz
(V_{DD} = 18 Vdc, V_{GG} = 7.0 Vdc, f = 200 MHz) (Figure 1)	MPF201		5.0	—	9.0	
(V_{DD} = 18 Vdc, f_{LO} = 245 MHz, f_{RF} = 200 MHz) (Figure 2)	MPF202		4.5	—	7.5	
(V_{DD} = 18 Vdc, V_{GG} = 6.0 Vdc, f = 45 MHz) (Figure 3)	MPF203		3.0	—	6.0	
Gain Control Gate-Supply Voltage(4)		$V_{GG(GC)}$				Vdc
(V_{DD} = 18 Vdc, ΔG_{ps} = −30 dB, f = 200 MHz) (Figure 1)	MPF201		0	−1.0	−3.0	
(V_{DD} = 18 Vdc, ΔG_{ps} = −30 dB, f = 45 MHz) (Figure 3)	MPF203		0	−0.6	−3.0	

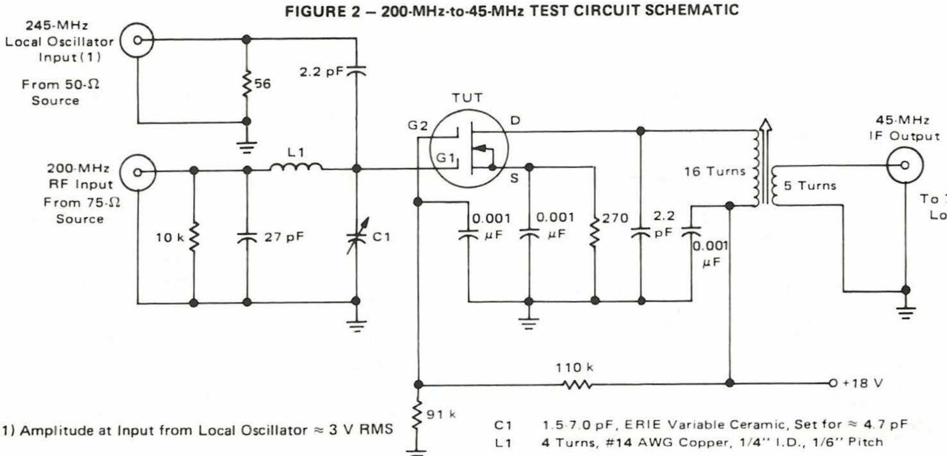
(1) All gate breakdown voltages are measured while the device is conducting rated gate current. This ensures that the gate-voltage limiting network is functioning properly.
(2) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.
(3) This parameter must be measured with bias voltages applied for less than 5 seconds to avoid overheating.
(4) ΔG_{ps} is defined as the change in G_{ps} from the value at V_{GG} = 7.0 volts (MPF201) and V_{GG} = 6.0 volts (MPF203).
(5) Power Gain Conversion

FIGURE 1 — 200-MHz TEST CIRCUIT SCHEMATIC



C1 4.0-30 pF, ERIE Variable Ceramic, Set for ≈ 22 pF
C2 4.0-30 pF, ERIE Variable Ceramic, Set for ≈ 10 pF
L1 4 Turns, #14 AWG Cooper, 1/4" I.D., 1/6" Pitch
L2 3 Turns, #14 AWG Cooper, 1/4" I.D., 1/8" Pitch
RFC DELEVAN No. 153712, 1.0 μH

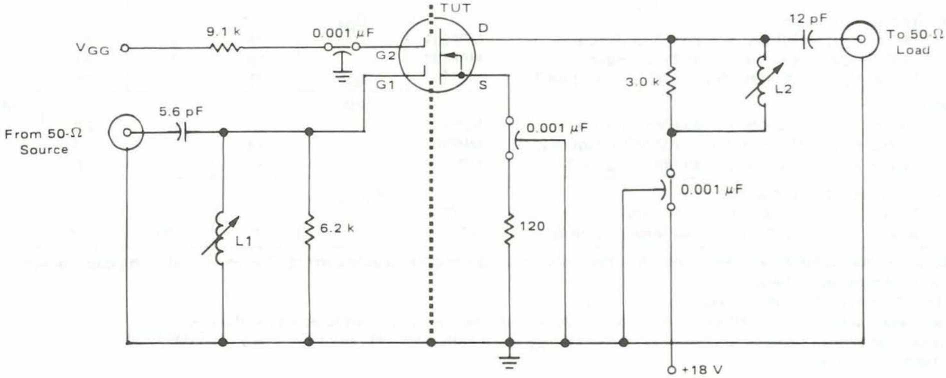
FIGURE 2 — 200-MHz-to-45-MHz TEST CIRCUIT SCHEMATIC



(1) Amplitude at Input from Local Oscillator ≈ 3 V RMS

C1 1.5-7.0 pF, ERIE Variable Ceramic, Set for ≈ 4.7 pF
L1 4 Turns, #14 AWG Copper, 1/4" I.D., 1/6" Pitch

FIGURE 3 — 45-MHz TEST CIRCUIT SCHEMATIC



L1 14 Turns, #30 AWG Copper, Close-Wound 7/32" OD form with ARNOLD ENGINEERING "J" Tuning Core

L2 10 Turns, #30 AWG Copper, Close-Wound 7/32" OD form with ARNOLD ENGINEERING "J" Tuning Core

6

TYPICAL CHARACTERISTICS

FIGURE 4 — DRAIN CURRENT versus DRAIN to SOURCE VOLTAGE

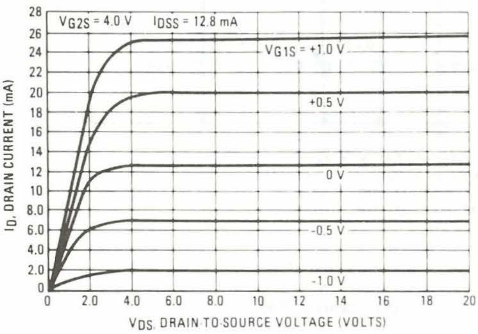


FIGURE 5 — DRAIN CURRENT versus GATE-ONE to SOURCE VOLTAGE

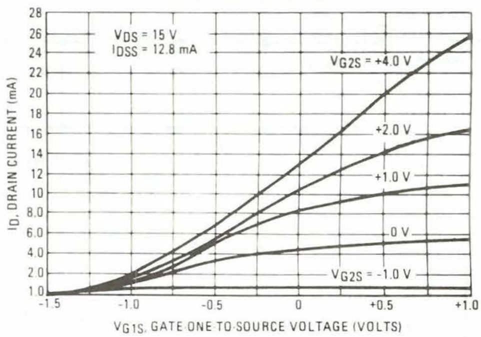


FIGURE 6 — SMALL-SIGNAL COMMON-SOURCE GATE-ONE FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

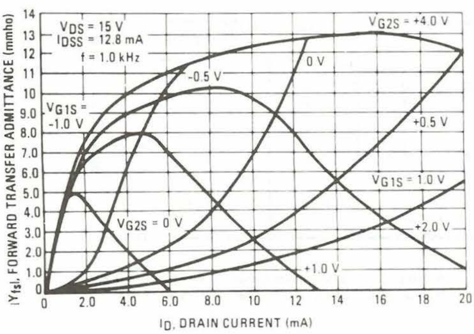


FIGURE 7 — SMALL-SIGNAL COMMON-SOURCE GATE-ONE FORWARD TRANSFER ADMITTANCE versus GATE-ONE to SOURCE VOLTAGE

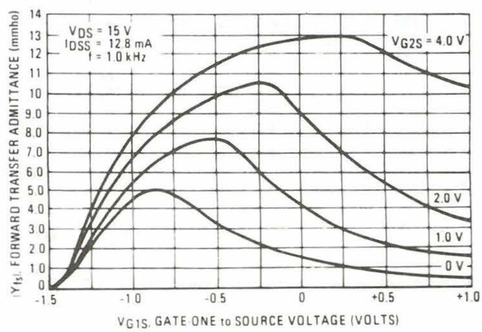


FIGURE 8 – SMALL-SIGNAL COMMON-SOURCE GATE-ONE FORWARD TRANSFER ADMITTANCE versus GATE-TWO to SOURCE VOLTAGE

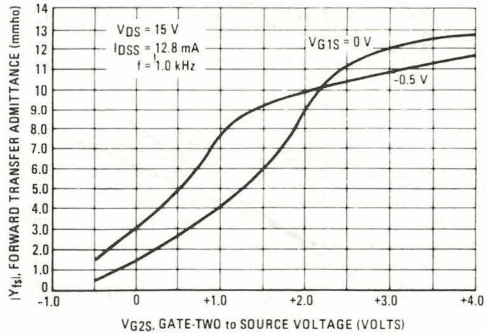
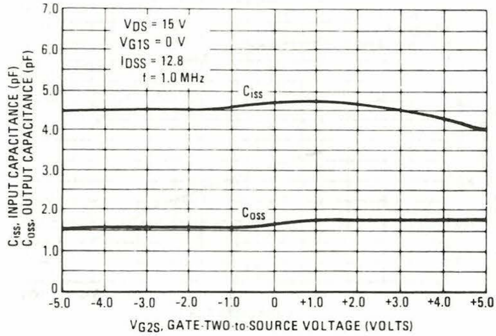


FIGURE 9 – SMALL-SIGNAL COMMON-SOURCE GATE-ONE INPUT AND OUTPUT CAPACITANCE versus GATE-TWO-to-SOURCE VOLTAGE



6

FIGURE 10 – COMMON-SOURCE POWER GAIN AND SPOT NOISE FIGURE versus DRAIN CURRENT

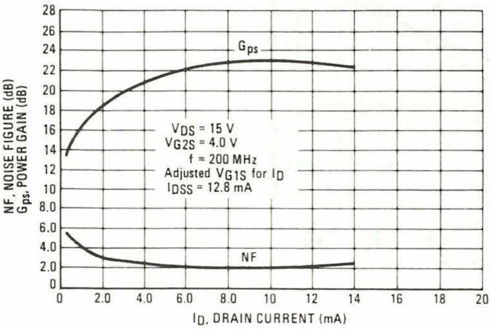


FIGURE 11 — COMMON-SOURCE POWER GAIN AND SPOT NOISE FIGURE versus GAIN CONTROL GATE-SUPPLY VOLTAGE — MPF201

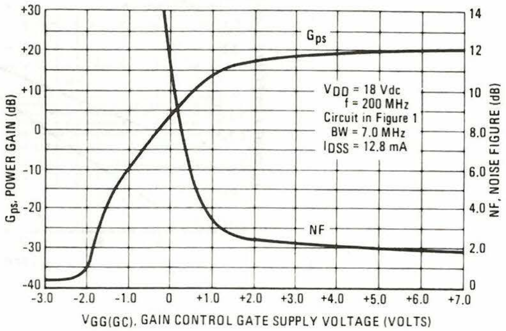


FIGURE 12 — SMALL-SIGNAL COMMON SOURCE INSERTION POWER GAIN versus GAIN CONTROL GATE-SUPPLY VOLTAGE — MPF203

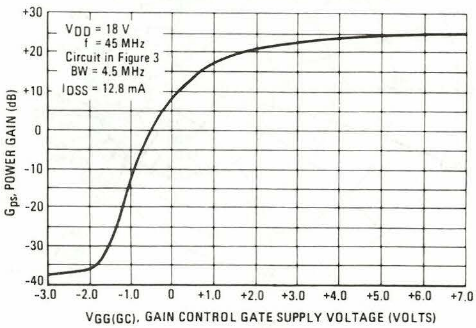


FIGURE 13 — SMALL-SIGNAL COMMON-SOURCE CONVERSION POWER GAIN versus LOCAL OSCILLATOR INPUT VOLTAGE — MPF202

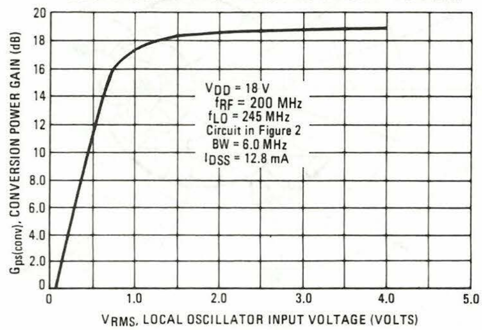


FIGURE 14 — SMALL-SIGNAL GATE ONE FORWARD TRANSFER ADMITTANCE versus FREQUENCY

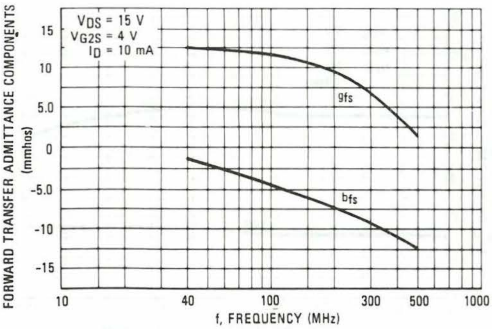


FIGURE 15 — SMALL-SIGNAL GATE ONE INPUT ADMITTANCE versus FREQUENCY

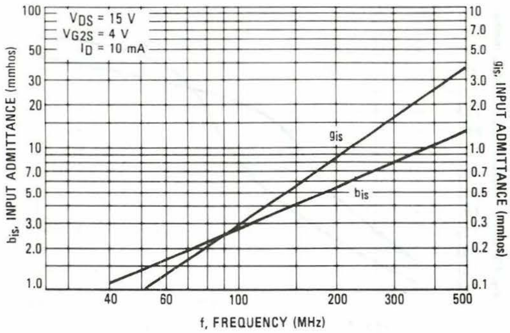


FIGURE 16 — SMALL-SIGNAL GATE ONE OUTPUT ADMITTANCE versus FREQUENCY

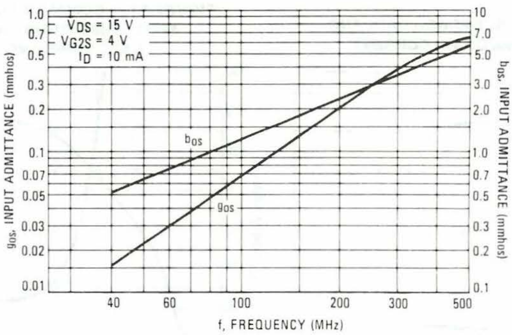
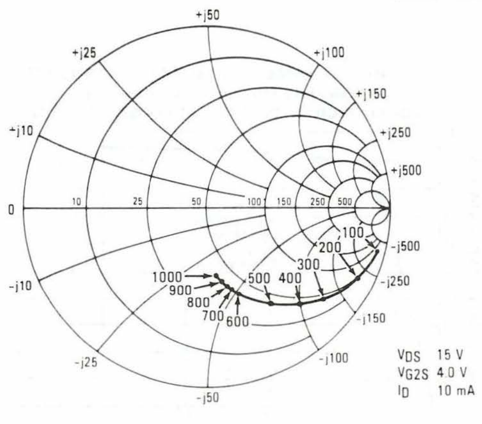
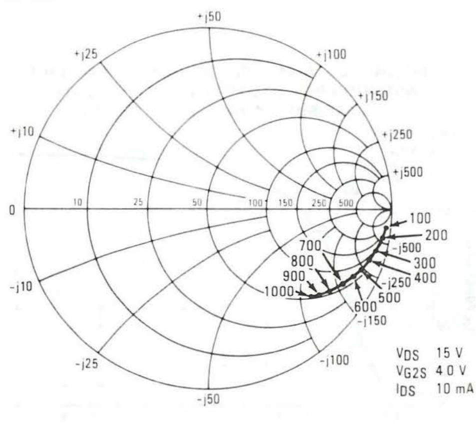


FIGURE 17 — S PARAMETERS PLOTTED ON 50 OHM SMITH CHART



S_{11}



S_{22}

MPF211
MPF212
MPF213

CASE 317-01, STYLE 1

DUAL-GATE MOSFET VHF AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	MPF211 MPF212	MPF213	Unit
Drain-Source Voltage	V_{DS}	27	35	Vdc
Drain-Gate Voltage	V_{DG1} V_{DG2}	35 35	40 40	Vdc
Drain Current — Continuous	I_D	50		mAdc
Gate Current	I_{G1} I_{G2}	±10 ±10		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.71		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 8.0		Watt mW/°C
Lead Temperature, 1/16″ From Seated Surface for 10 Seconds	T_L	260		°C
Junction Temperature Range	T_J	−65 to +150		°C
Storage Channel Temperature Range	T_{stg}	−65 to +150		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (V_{G1S} = V_{G2S} = −4.0 Vdc, I_D = 10 μAdc)	 MPF211,212 MPF213	$V_{(BR)DSX}$	 25 30	 — —	Vdc
Instantaneous Drain-Source Breakdown Voltage(1) (V_{G1S} = V_{G2S} = −4.0 Vdc, I_D = 10 μAdc)	 MPF211,212 MPF213	$V_{(BR)DSX}$	 27 35	 — —	Vdc
Gate 1-Source Breakdown Voltage(2) (V_{G2S} = V_{DS} = 0, I_{G1} = ±10 mAdc)		$V_{(BR)G1SO}$	±6.0	—	Vdc
Gate 2-Source Breakdown Voltage(2) (V_{G1S} = V_{DS} = 0, I_{G2} = ±10 mAdc)		$V_{(BR)G2SO}$	±6.0	—	Vdc
Gate 1 Leakage Current (V_{G1S} = ±5.0 Vdc, V_{G2S} = V_{DS} = 0) (V_{G1S} = −5.0 Vdc, V_{G2S} = V_{DS} = 0, T_A = 150°C)		I_{G1SS}	 ±0.04(Typ) —	 ±100 −100	 nAdc μAdc
Gate 2 Leakage Current (V_{G2S} = ±5.0 Vdc, V_{G1S} = V_{DS} = 0) (V_{G2S} = −5.0 Vdc, V_{G1S} = V_{DS} = 0, T_A = 150°C)		I_{G2SS}	 ±0.04(Typ) —	 ±100 −100	 nAdc μAdc
Gate 1 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 2.0 μAdc)	 MPF211,213 MPF212	$V_{G1S(off)}$	 −0.5 −0.5	 −5.5 −4.0	Vdc
Gate 2 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G1S} = 0, I_D = 20 μAdc)	 MPF211 MPF212,213	$V_{G2S(off)}$	 −0.2 −0.2	 −2.5 −4.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(3) (V_{DS} = 15 Vdc, V_{G1S} = 0, V_{G2S} = 4.0 Vdc)		I_{DSS}	6.0	4.0	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance(4) (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, V_{G1S} = 0, f = 1.0 kHz)	 MPF211,212 MPF213	$\|Y_{fs}\|$	 17 15	 40 35	mmhos
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, f = 1.0 MHz)		C_{rss}	0.005	0.05	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DD} = 18 Vdc, V_{GG} = 7.0 Vdc, f = 200 MHz) (Figure 1) (V_{DD} = 24 Vdc, V_{GG} = 6.0 Vdc, f = 45 MHz) (Figure 2)	 MPF211 MPF211,213	NF	 — —	 4.0 4.5	dB

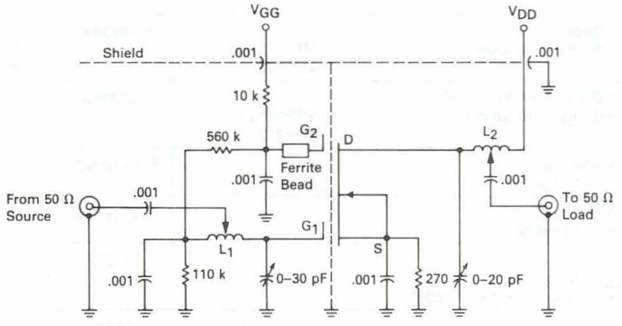
ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Common Source Power Gain		G_{ps}			dB
(V_{DD} = 18 Vdc, V_{GG} = 7.0 Vdc, f = 200 MHz) (Figure 1)	MPF211		24	35	
(V_{DD} = 24 Vdc, V_{GG} = 6.0 Vdc, f = 45 MHz) (Figure 2)	MPF211		29	37	
(V_{DD} = 24 Vdc, V_{GG} = 6.0 Vdc, f = 45 MHz) (Figure 2)	MPF213		27	35	
(V_{DD} = 18 Vdc, f_{LO} = 245 MHz, f_{RE} = 200 MHz) (Figure 3)	MPF212	G_c(6)	21	38	
Bandwidth		BW			MHz
(V_{DD} = 18 Vdc, V_{GG} = 7.0 Vdc, f = 200 MHz) (Figure 1)	MPF211		5.0	12	
(V_{DD} = 18 Vdc, f_{LO} = 245 MHz, f_{RE} = 200 MHz) (Figure 3)	MPF212		4.0	7.0	
(V_{DD} = 24 Vdc, V_{GG} = 6.0 Vdc, f = 45 MHz) (Figure 2)	MPF211,213		3.5	6.0	
Gain Control Gate-Supply Voltage(5)		$V_{GG(GC)}$			Vdc
(V_{DD} = 18 Vdc, ΔG_{ps} = −30 dB, f = 200 MHz) (Figure 1)	MPF211		—	−2.0	
(V_{DD} = 24 Vdc, ΔG_{ps} = −30 dB, f = 45 MHz) (Figure 2)	MPF211,213		—	±1.0	

(1) Measured after five seconds of applied voltage.
(2) All gate breakdown voltages are measured while the device is conducting rated gate current. This ensures that the gate voltage limiting network is functioning properly.
(3) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.
(4) This parameter must be measured with bias voltages applied for less than 5 seconds to avoid overheating. The signal is applied to Gate 1 with Gate 2 at ac ground.
(5) ΔG_{ps} is defined as the change in G_{ps} from the value at V_{GG} = 7.0 Volts (MPF211) and V_{GG} = 6.0 Volts (MPF213).
(6) Power Gain Conversion. Amplitude at input from local oscillator is adjusted for maximum G_c.

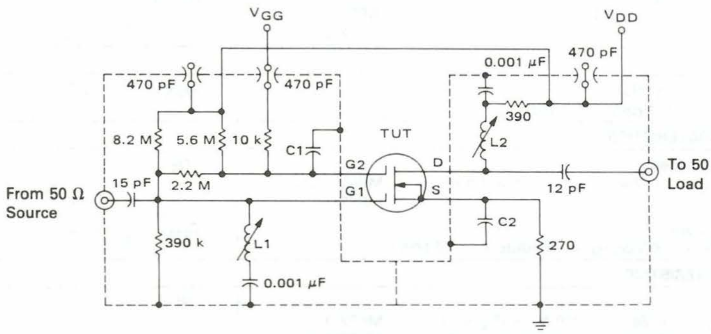
6

FIGURE 1 — 200 MHz POWER GAIN, GAIN CONTROL VOLTAGE, AND NOISE FIGURE TEST CIRCUIT



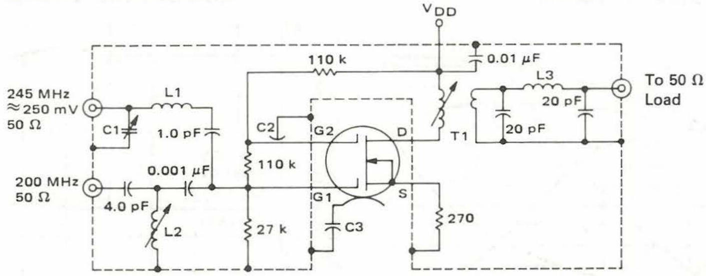
L_1 2½ T #18, ¼″ diameter center tapped
L_2 3½ T #18, 5/16″ diameter tapped ½T from cold end
C = μF unless otherwise specified

FIGURE 2 — 45-MHz POWER GAIN AND NOISE FIGURE TEST CIRCUIT



C1: Leadless disc ceramic, 0.001 μF
C2: Leadless disc ceramic, 0.01 μF
L1: 8 Turns #28, 5/32″ diameter form, type "J" slug
L2: 9 Turns #28, 5/32″ diameter form, type "J" slug

FIGURE 3 — 200-MHz-to-45-MHz CIRCUIT FOR CONVERSION POWER GAIN



L1: 7 Turns #34, 1/4" diameter aluminum slug
L2: 5-1/2 Turns #20, 1/4" diameter aluminum slug
L3: 7 Turns #24, 1/4" diameter air core

C1: Arco type 462, 5-80 pF
C2: 0.001 μF leadless disc
C3: 0.01 μF leadless disc

T1: Pri: 25 Turns #30, close wound on 1/4" diameter form, type "J" slug
Sec: 4 Turns #30, centered over primary

TYPICAL CHARACTERISTICS

FIGURE 4 — DRAIN CURRENT versus DRAIN-TO-SOURCE VOLTAGE

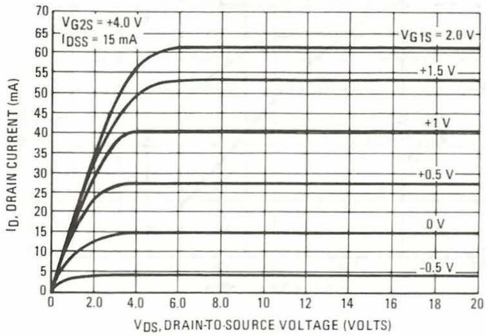
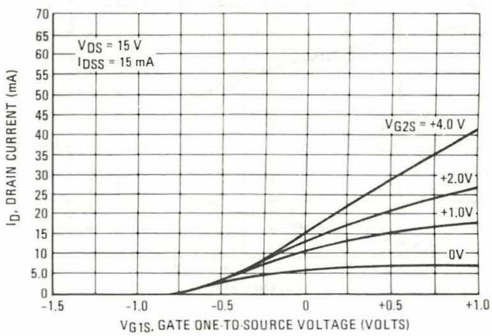


FIGURE 5 — DRAIN CURRENT versus GATE ONE-TO-SOURCE VOLTAGE



SMALL-SIGNAL COMMON-SOURCE PARAMETER — GATE ONE

FIGURE 6 — FORWARD TRANSFER ADMITTANCE versus GATE TWO-TO-SOURCE VOLTAGE

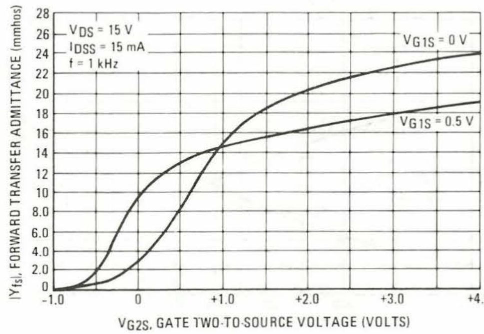


FIGURE 7 — FORWARD TRANSFER ADMITTANCE versus GATE ONE-TO-SOURCE VOLTAGE

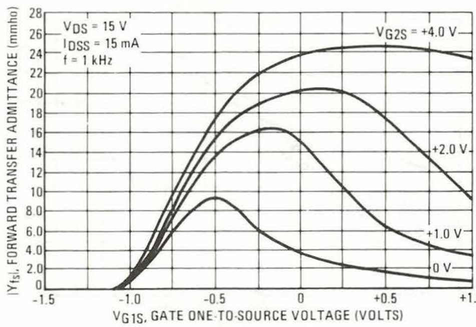


FIGURE 8 — FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

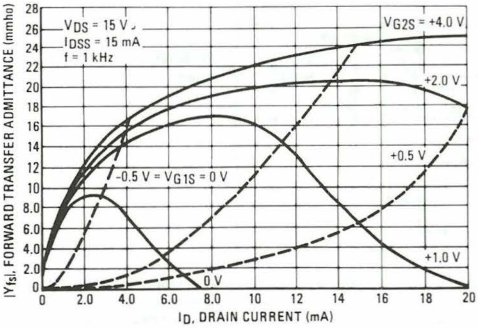
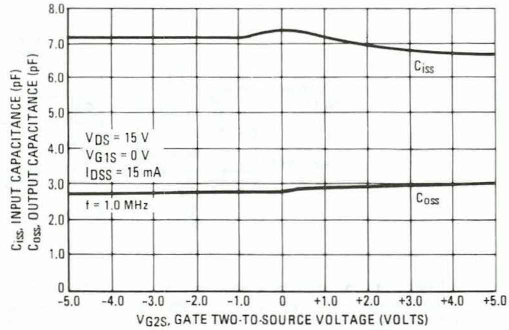


FIGURE 9 — INPUT AND OUTPUT CAPACITANCE versus GATE TWO-TO-SOURCE VOLTAGE



6

FIGURE 10 — SMALL-SIGNAL GATE ONE INPUT ADMITTANCE versus FREQUENCY

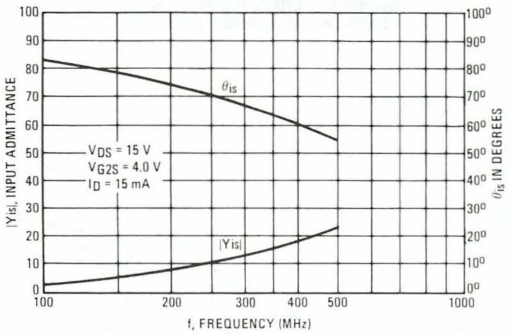


FIGURE 11 — SMALL-SIGNAL FORWARD TRANSFER ADMITTANCE versus FREQUENCY

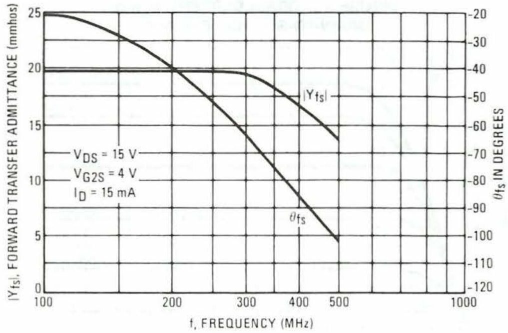


FIGURE 12 — SMALL-SIGNAL GATE ONE REVERSE TRANSFERS ADMITTANCE versus FREQUENCY

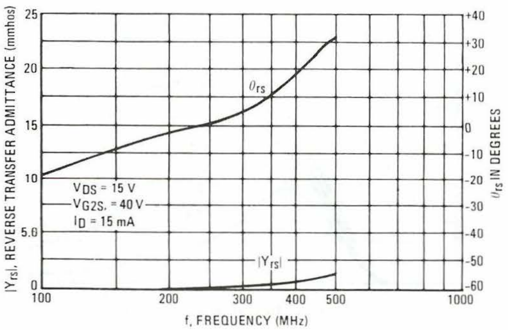


FIGURE 13 — SMALL-SIGNAL GATE ONE OUTPUT ADMITTANCE versus FREQUENCY

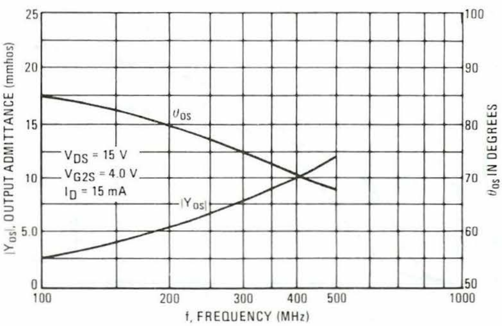


FIGURE 14 — RELATIVE SMALL-SIGNAL POWER GAIN versus GAIN CONTROL GATE SUPPLY VOLTAGE MPF211

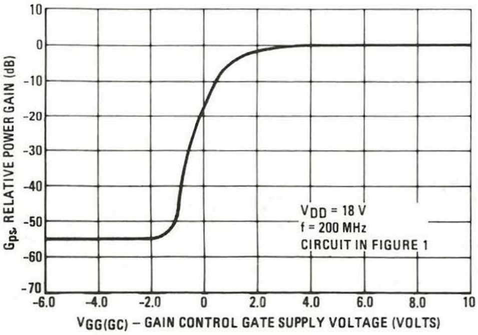


FIGURE 15 — COMMON SOURCE SPOT NOISE FIGURE versus GAIN CONTROL GATE SUPPLY VOLTAGE MPF211

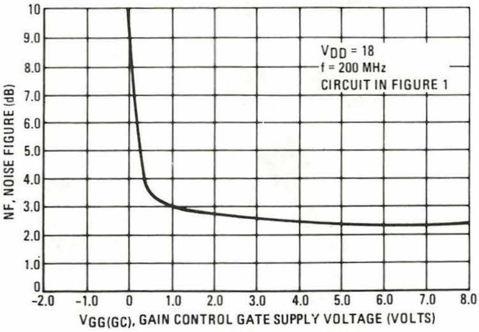


FIGURE 16 — SMALL-SIGNAL COMMON-SOURCE INSERTION POWER GAIN versus GAIN CONTROL GATE SUPPLY VOLTAGE MPF211, 213

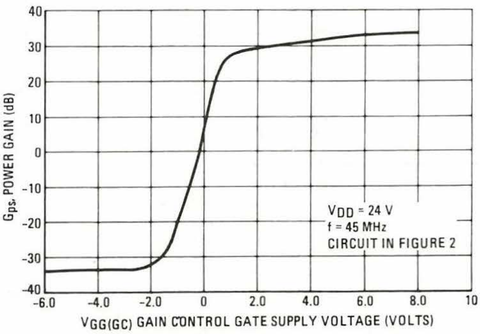


FIGURE 17 — OPTIMUM SPOT NOISE FIGURE versus FREQUENCY

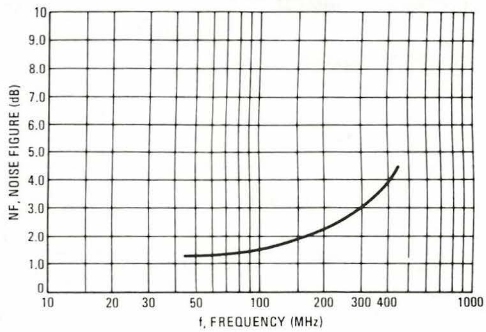
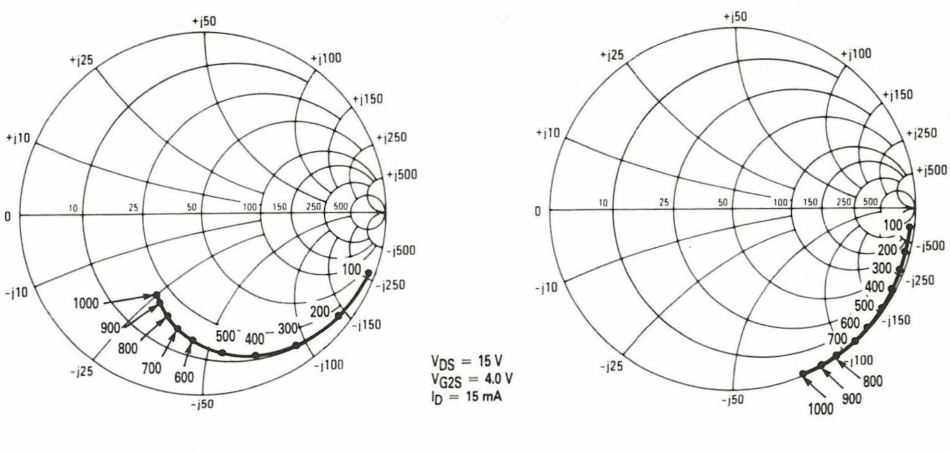


FIGURE 18 — INPUT/OUTPUT IMPEDANCE



MPF230
MPF231
MPF232

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
LOW NOISE AMPLIFIER

N-CHANNEL — DEPLETION

Refer to 2N4220 for graphs.

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	−40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Gate-Source Voltage	V_{GS}	40	Vdc
Gate Current	I_G	50	mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	310 2.82	mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = -1.0\ \mu A$)		$V_{(BR)GSS}$	−40	—	Vdc
Gate Reverse Current ($V_{GS} = -30$ V)		I_{GSS}	—	−250	pA
Gate Source Cutoff Voltage ($V_{DS} = 20$ V, $I_D = 1.0\ \mu A$)	MPF230 MPF231 MPF232	$V_{GS(off)}$	−1.0 −2.0 −3.0	−3.0 −5.0 −6.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current ($V_{DS} = 20$ V)	MPF230 MPF231 MPF232	I_{DSS}*	0.7 2.0 5.0	3.0 6.0 10.0	mA
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance ($V_{DS} = 20$ V, f = 1.0 kHz)	MPF230 MPF231 MPF232	$\|y_{fs}\|$*	1000 1500 2500	3000 3000 4500	μmhos
FUNCTIONAL CHARACTERISTICS					
Equivalent Short-Circuit Input Noise Voltage ($V_{DS} = 10$ V, f = 10 Hz)		$\overline{e}_n$		30	nV/$\sqrt{Hz}$

*Pulse Width ≤ 2.0 msec.

MPF256

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
AMPLIFIER

N-CHANNEL — DEPLETION

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	±30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	30	Vdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.73	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	25	—	—	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)		I_{GSS}	—	—	5.0	nAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 200 μAdc)		$V_{GS(off)}$	0.5	—	7.5	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	Red Green Violet	I_{DSS}*	3.0 6.0 11	— — —	7.0 13 18	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)		$\lvert y_{fs} \rvert$	6.0	—	—	mmhos
Input Capacitance (V_{DS} = 15 Vdc, I_D = 10 mAdc, f = 1.0 MHz)		C_{iss}	—	3.0	—	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, I_D = 10 mAdc, f = 1.0 MHz)		C_{rss}	—	1.2	—	pF
Output Capacitance (V_{DS} = 15 Vdc, I_D = 10 mAdc, f = 1.0 kHz)		C_{oss}	—	2.0	—	pF
FUNCTIONAL CHARACTERISTICS						
Noise Figure (V_{DS} = 15 Vdc, R_S = 50 Ohms)	100 MHz 400 MHz	NF	— —	— —	2.0 4.0	dB
Common Source Power Gain (V_{DS} = 15 Vdc, R_S = 50 Ohms)	100 MHz 400 MHz	G_{ps}	20 12	— —	— —	dB

*To characterize these devices to narrower limits, the entire production lot is tested and divided into color-coded groups, with each color dot representing an I_{DSS} range.

When packaged for shipment, the colors are randomly selected and no specific color distribution is implied or guaranteed.

MPF521

CASE 317-01, STYLE 1

MOSFET
DUAL GATE
VHF AMPLIFIER TRANSISTOR

N-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG1} V_{DG2}	30 30	Vdc
Drain Current	I_D	30	mAdc
Gate Current	I_{G1F} I_{G2F}	10 10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.71	mW mW/°C
Operating Channel Temperature	$T_{channel}$	150	°C
Lead Temperature, 1/16″ From Seated Surface for 10 Seconds	T_L	200	°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C

6

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

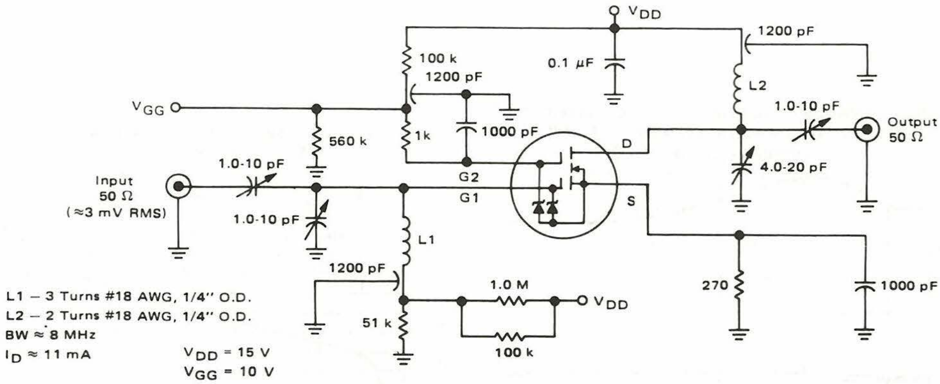
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate 1-Source Breakdown Voltage (V_{G2} = V_{DS} = 0, I_{G1} = 10 μAdc)	$V_{(BR)G1SO}$	10	15	—	Vdc
Gate 2-Source Breakdown Voltage (V_{G1S} = V_{DS} = 0, I_{G2} = 10 μAdc)	$V_{(BR)G2SO}$	12	16	—	Vdc
Gate 1 Reverse Leakage Current (V_{G1S} = 5.0 Vdc, V_{G2S} = V_{DS} = 0)	I_{G1SS}	—	30	100	nAdc
Gate 2 Reverse Leakage Current (V_{G2S} = 5.0 Vdc, V_{G1S} = V_{DS} = 0)	I_{G2SS}	—	30	100	nAdc
Drain-Source Breakdown Voltage (V_{G2} = 0, I_D = 10 μAdc)	$V_{(BR)DS}$	25	28	—	Vdc
ON CHARACTERSTICS					
Gate-Source Threshold Voltage (V_{G2S} = 10 Vdc, I_D = 10 μAdc, V_{DS} = 15 V) (V_{G1S} = 4.0 Vdc, I_D = 10 μAdc, V_{DS} = 15 V)	$V_{G1S(TH)}$ $V_{G2S(TH)}$	 0.5 0.5	 1.2 1.0	 2.0 2.0	Vdc
Gate-Source On Voltage (V_{DS} = 15 Vdc, V_{G2S} = 10 Vdc, I_D = 10 mAdc)	$V_{G1S(on)}$	2.0	2.6	4.0	Vdc
"On" Drain Current (V_{DS} = 15 Vdc, V_{G2S} = 10 Vdc, V_{G1S} = 3.0 Vdc)	$I_{D(on)}$	5.0	15	20	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance(1) (V_{DS} = 15 Vdc, V_{G2S} = 10 Vdc, I_D = 10 mAdc, f = 1.0 kHz) (V_{DS} = 15 Vdc, V_{G2S} = 10 Vdc, I_D = 10 mAdc, f = 200 MHz)	 $\|y_{fs}\|$ y_{fs}	 10 —	 12 10.57-j6.86	 20 —	mmhos
Input Admittance(1) (V_{DS} = 15 Vdc, V_{G2S} = 10 Vdc, I_D = 10 mAdc, f = 200 MHz)	y_{is}	—	0.524+j4.27	—	mmhos
Reverse Transfer Admittance(1) (V_{DS} = 15 Vdc, V_{G2S} = 10 Vdc, I_D = 10 mAdc, f = 200 MHz)	y_{rs}	—	-1.7-j9.8	—	μmhos
Output Admittance(1) (V_{DS} = 15 Vdc, V_{G2S} = 10 Vdc, I_D = 10 mAdc, f = 200 MHz)	$\|y_{os}\|$	—	0.126+j1.79	—	mmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 10 Vdc, V_{G1} = 2.5 Vdc, f = 1.0 MHz)	C_{iss}	—	3.3	4.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 10 Vdc, V_{G1} = 2.5 Vdc, f = 1.0 MHz)	C_{rss}	—	0.015	0.03	pF
Output Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 10 Vdc, V_{G1} = 2.5 Vdc, f = 1.0 MHz)	C_{oss}	—	1.1	2.5	pF

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL CHARACTERISTICS					
Noise Figure (Figures 1 and 9) (V_{DS} = 15 Vdc, V_{GG} = 10 V, f = 200 MHz)	NF	—	1.7	3.5	dB
Common Source Power Gain (Figures 1 and 9) (V_{DS} = 15 Vdc, V_{GG} = 10 V, f = 200 MHz, BW = 7.0 MHz (Min))	G_{ps}	21	25	—	dB

(1) All y-parameters are with respect to Gate 1.

FIGURE 1 — 200 MHz NOISE FIGURE AND POWER GAIN TEST CIRCUIT



TYPICAL CHARACTERISTICS

FIGURE 2 — DRAIN CURRENT versus DRAIN to SOURCE VOLTAGE

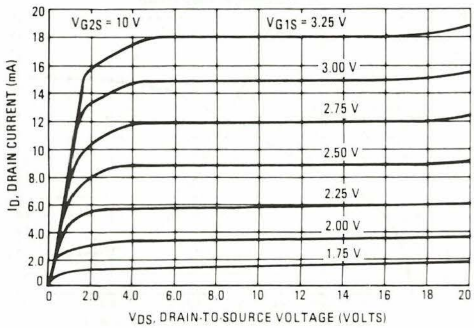
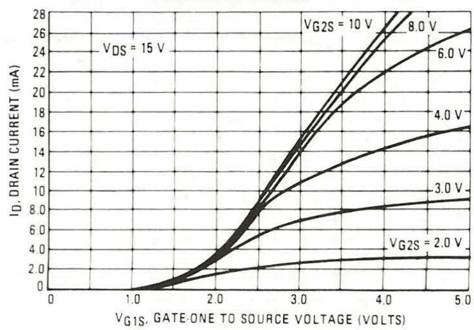


FIGURE 3 — DRAIN CURRENT versus GATE-ONE to SOURCE VOLTAGE



6

FIGURE 4 – SMALL-SIGNAL COMMON-SOURCE GATE-ONE FORWARD TRANSFER ADMITTANCE versus GATE-ONE to SOURCE VOLTAGE

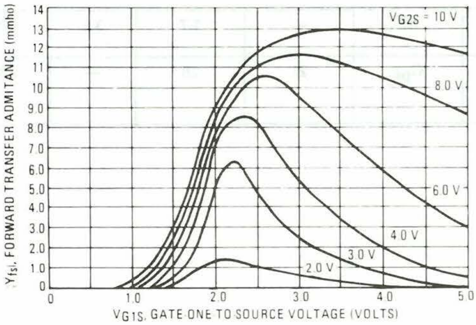


FIGURE 5 – SMALL-SIGNAL COMMON-SOURCE GATE-ONE FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

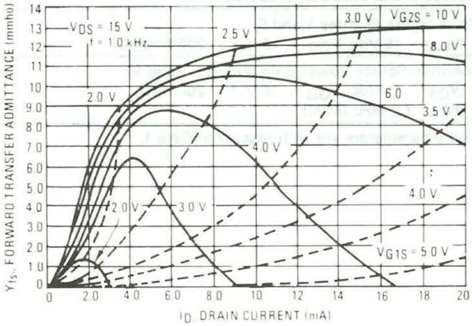


FIGURE 6 – SMALL-SIGNAL COMMON-SOURCE GATE-ONE INPUT AND OUTPUT CAPACITANCE versus GATE-TWO to SOURCE VOLTAGE

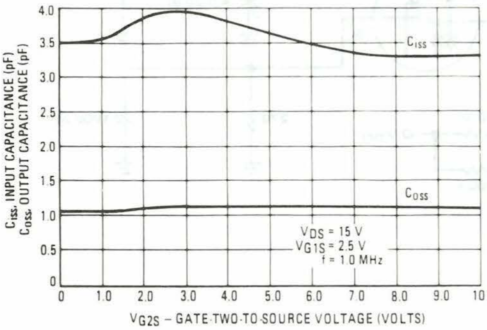


FIGURE 7 – COMMON SOURCE POWER GAIN versus DRAIN SUPPLY CURRENT

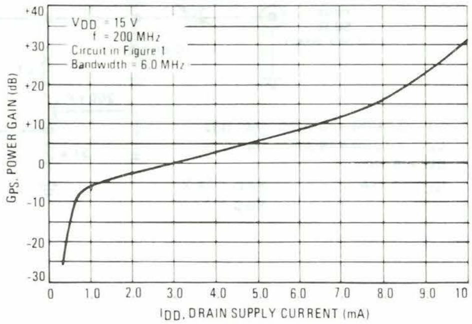


FIGURE 8 – COMMON SOURCE POWER GAIN AND SPOT NOISE FIGURE versus DRAIN CURRENT

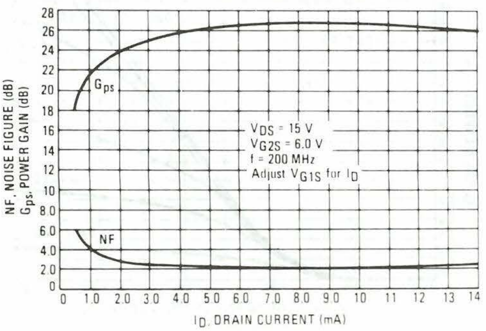


FIGURE 9 – COMMON SOURCE POWER GAIN AND SPOT NOISE FIGURE versus GAIN CONTROL GATE-SUPPLY VOLTAGE

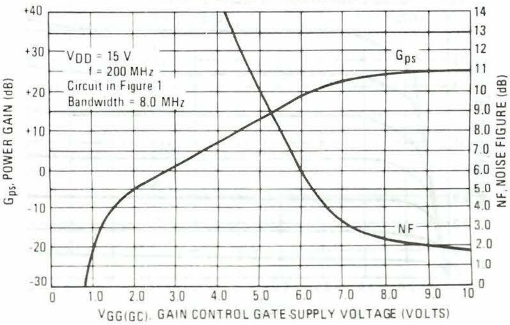


FIGURE 10 — SMALL-SIGNAL GATE ONE INPUT ADMITTANCE versus FREQUENCY

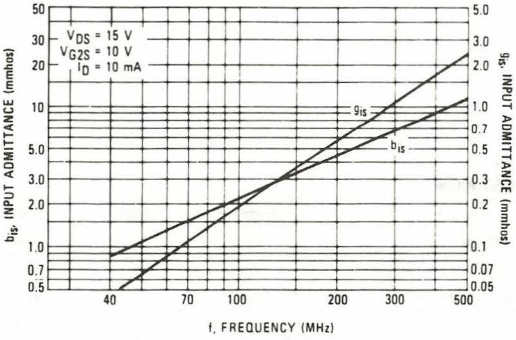


FIGURE 11 — SMALL-SIGNAL COMMON SOURCE GATE ONE FORWARD TRANSFER ADMITTANCE versus FREQUENCY

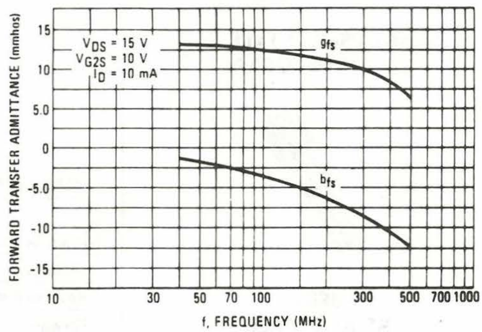


FIGURE 12 — SMALL-SIGNAL COMMON SOURCE OUTPUT ADMITTANCE versus FREQUENCY

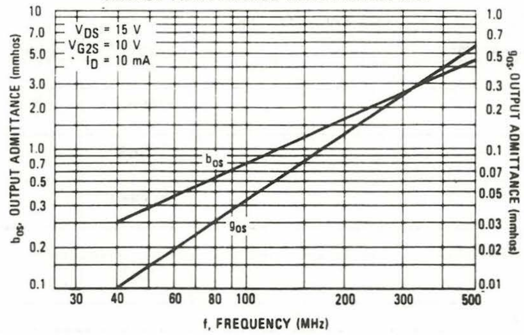
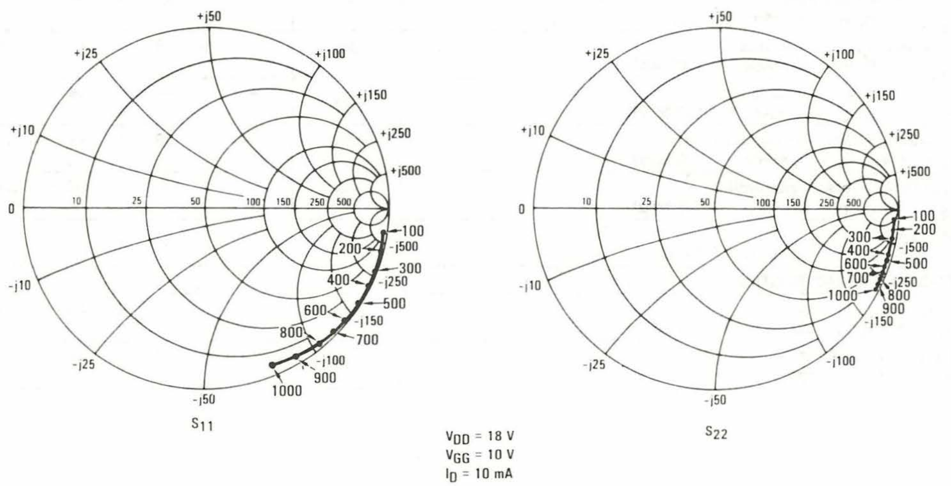


FIGURE 13 — INPUT/OUTPUT IMPEDANCE



6

MPF820

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
RF AMPLIFIER

N-CHANNEL — DEPLETION

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	25	Vdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = 10\ \mu Adc$, $V_{DS} = 0$)	$V_{(BR)GSS}$	25	—	—	Vdc
Gate Reverse Current ($V_{GS} = 15$ Vdc, $V_{DS} = 0$)	I_{GSS}	—	—	5.0	nAdc
Gate Source Cutoff Voltage ($V_{DS} = 15$ Vdc, $I_D = 200\ \mu Adc$)	$V_{GS(off)}$	—	—	5.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain ($V_{DS} = 15$ Vdc, $V_{GS} = 0$)	I_{DSS}	10	—	—	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)	$\|y_{fs}\|$	—	20	—	mmhos
Input Capacitance ($V_{DS} = 15$ Vdc, $I_D = 10$ mAdc, f = 1.0 MHz)	C_{iss}	—	15	—	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ Vdc, $I_D = 10$ mAdc, f = 1.0 MHz)	C_{rss}	—	3.5	—	pF
Common-Gate Input Conductance ($V_{DS} = 15$ Vdc, $I_D = 10$ mAdc, f = 100 MHz)	g_{ig}	—	16	—	mmhos
Common-Gate Output Conductance ($V_{DS} = 15$ Vdc, $I_D = 10$ mAdc, f = 100 MHz)	G_{og}	—	—	16	μmhos
Common-Gate Forward Transadmittance ($V_{DS} = 15$ Vdc, $I_D = 10$ mAdc, f = 100 MHz)	y_{fg}	—	18	—	mmhos
Common-Gate Reverse Transadmittance ($V_{DS} = 15$ Vdc, $I_D = 10$ mAdc, f = 100 MHz)	y_{rg}	—	—	130	μmhos
Output Capacitance ($V_{DS} = 15$ Vdc, $I_D = 10$ mAdc, f = 1.0 kHz)	C_{oss}	—	3.5	—	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure ($V_{DS} = 15$ Vdc, $I_D = 10$ mAdc, See Figure 5)	NF	—	—	4.0	dB
Small-Signal Power Gain ($V_{DS} = 15$ Vdc, $I_D = 10$ mAdc, See Figure 5)	G_{pg}	—	11	—	dB

FIGURE 1 – NOISE FIGURE

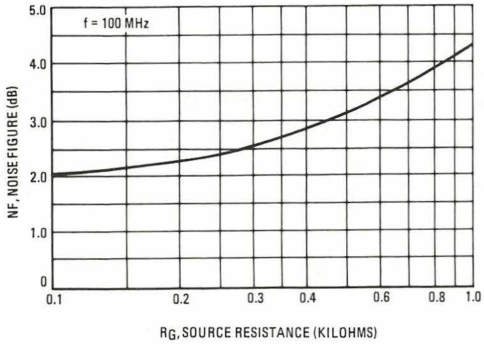


FIGURE 2 – FORWARD TRANSADMITTANCE

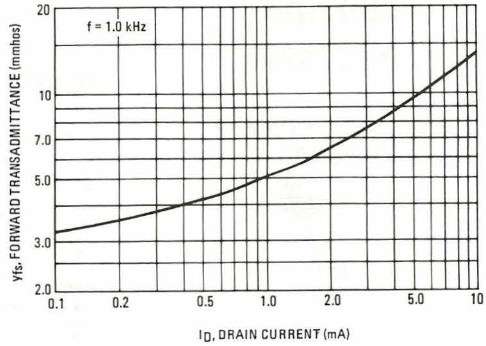


FIGURE 3 – INPUT CAPACITANCE

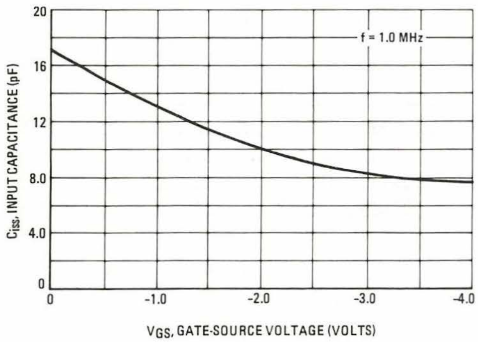
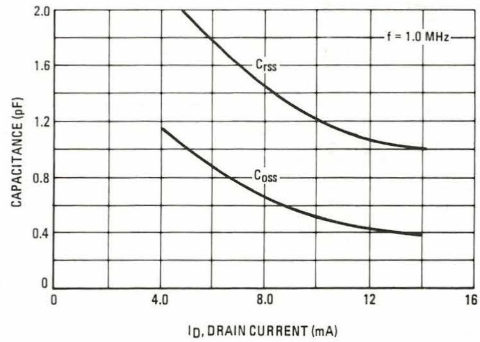
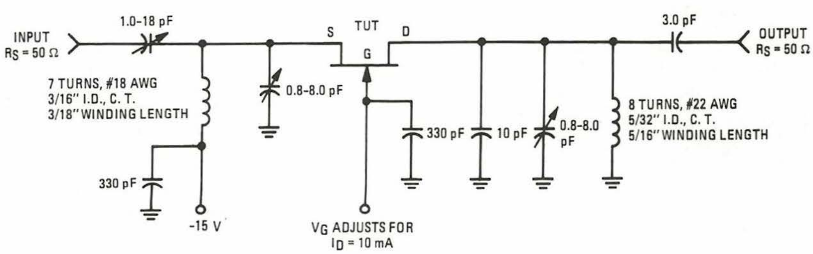


FIGURE 4 – OUTPUT AND REVERSE TRANSFER CAPACITANCE



6

FIGURE 5 – 100 MHz TEST CIRCUIT



MPF930
MPF960
MPF990

CASE 29-03, STYLE 22
TO-226AE

TMOS
SWITCHING

N-CHANNEL — ENHANCEMENT

Refer to MFE930 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPF930	MPF960	MPF990	Unit
Drain-Source Voltage	V_{DS}	35	60	90	Vdc
Drain-Gate Voltage	V_{DG}	35	60	90	Vdc
Gate-Source Voltage	V_{GS}		±30		Vdc
Drain Current Continuous (1) Pulsed (2)	 I_D I_{DM}		 2.0 3.0		Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D		 1.0 8.0		 Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		−55 to 150		°C
Thermal Resistance	θ_{JA}		125		°C/W

(1) The Power Dissipation of the package may result in a lower continuous drain current.
(2) Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 10 μA)	MPF930 MPF960 MPF990	$V_{(BR)DSX}$	35 60 90	— — —	— — —	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)		I_{GSS}	—	—	50	nAdc
ON CHARACTERISTICS*						
Zero-Gate-Voltage Drain Current (V_{DS} = Maximum Rating, V_{GS} = 0)		I_{DSS}	—	—	10	μAdc
Gate Threshold Voltage (I_D = 1.0 mA, V_{DS} = V_{GS})		$V_{GS(Th)}$	1.0	—	3.5	Vdc
Drain-Source On-Voltage (V_{GS} = 10 V) (I_D = 0.5 A)	MPF930 MPF960 MPF990	$V_{DS(on)}$	— — —	0.4 0.6 0.6	0.7 0.8 1.2	Vdc
(I_D = 1.0 A)	MPF930 MPF960 MPF990		— — —	0.9 1.2 1.2	1.4 1.7 2.4	
(I_D = 2.0 A)	MPF930 MPF960 MPF990		— — —	2.2 2.8 2.8	3.0 3.5 4.8	
Static Drain-Source On Resistance (V_{GS} = 10 Vdc, I_D = 1.0 Adc)	MPF930 MPF960 MPF990	$r_{DS(on)}$	— — —	0.9 1.2 1.2	1.4 1.7 2.0	Ohms
On-State Drain Current (V_{DS} = 25 V, V_{GS} = 10 V)		$I_{D(on)}$	1.0	2.0	—	Amps
SMALL-SIGNAL CHARACTERISTICS						
Input Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	60	70	pF
Reverse Transfer Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	13	18	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1.0 MHz)		C_{oss}	—	49	60	pF
Forward Transconductance (V_{DS} = 25 V, I_D = 0.5 A)		g_{fs}	200	380	—	mmhos
SWITCHING CHARACTERISTICS						
Turn-On Time		t_{on}	—	7.0	15	ns
Turn-Off Time		t_{off}	—	7.0	15	ns

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPF970
MPF971

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
SWITCHING

P-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	30	Vdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Storage Channel Temperature Range	T_{stg}	−65 to +150	°C
Operating Temperature Range	$T_{channel}$	−65 to +150	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage ($I_G = 1.0\ \mu$Adc, $V_{DS} = 0$)		$V_{(BR)GSS}$	30	—	—	Vdc
Gate Reverse Current ($V_{GS} = 15$ Vdc, $V_{DS} = 0$) ($V_{GS} = 15$ Vdc, $V_{DS} = 0$, $T_A = 150°C$)		I_{GSS}	 — —	 — —	 1.0 1.0	 nAdc μAdc
Drain-Cutoff Current ($V_{DS} = 15$ Vdc, $V_{GS} = 12$ Vdc) ($V_{DS} = 15$ Vdc, $V_{GS} = 12$ Vdc, $T_A = 150°C$) ($V_{DS} = 15$ Vdc, $V_{GS} = 7.0$ Vdc) ($V_{DS} = 15$ Vdc, $V_{GS} = 7.0$ Vdc, $T_A = 150°C$)	 MPF970 MPF970 MPF971 MPF971	$I_{D(off)}$	 — — — —	 — — — —	 10 10 10 10	 nAdc μAdc nAdc μAdc
Gate Source Cutoff Voltage ($V_{DS} = 15$ Vdc, $I_D = 10$ nAdc)	 MPF970 MPF971	$V_{GS(off)}$	 5.0 1.0	 — —	 12 7.0	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current(1) ($V_{DS} = 20$ Vdc, $V_{GS} = 0$)	 MPF970 MPF971	I_{DSS}	 15 2.0	 — —	 100 50	mAdc
Drain-Source On-Voltage ($I_D = 10$ mAdc, $V_{GS} = 0$) ($I_D = 1.5$ mAdc, $V_{GS} = 0$)		$V_{DS(on)}$	 — —	 — —	 1.5 1.5	Vdc
Static Drain-Source On Resistance ($I_D = 1.0$ mAdc, $V_{GS} = 0$)	 MPF970 MPF971	$r_{DS(on)}$	 — —	 — —	 100 250	Ohms
SMALL-SIGNAL CHARACTERISTICS						
Drain-Source "ON" Resistance ($V_{GS} = 0$, $I_D = 0$, f = 1.0 kHz)	 MPF970 MPF971	$r_{ds(on)}$	 — —	 — —	 100 250	Ohms
Input Capacitance ($V_{GS} = 12$ Vdc, $V_{DS} = 0$, f = 1.0 MHz) ($V_{GS} = 7.0$ Vdc, $V_{DS} = 0$, f = 1.0 MHz)	 MPF970 MPF971	C_{iss}	 — —	 — —	 12 12	pF
Reverse Transfer Capacitance ($V_{GS} = 12$ Vdc, $V_{DS} = 0$, f = 1.0 MHz) ($V_{GS} = 7.0$ Vdc, $V_{DS} = 0$, f = 1.0 MHz)	 MPF970 MPF971	C_{rss}	 — —	 — —	 5.0 5.0	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
SWITCHING CHARACTERISTICS (See Figure 6, R_K = 0) (1)						
Rise Time		t_r				ns
($I_{D(on)}$ = 10 mAdc, $V_{GS(off)}$ = 12 Vdc)	MPF970		—	2.0	5.0	
($I_{D(on)}$ = 1.5 mAdc, $V_{GS(off)}$ = 7.0 Vdc)	MPF971		—	3.0	5.0	
Fall Time		t_f				ns
($I_{D(on)}$ = 10 mAdc, $V_{GS(off)}$ = 12 Vdc)	MPF970		—	9.0	15	
($I_{D(on)}$ = 1.5 mAdc, $V_{GS(off)}$ = 7.0 Vdc)	MPF971		—	68	80	
Turn-On Time		t_{on}				ns
($I_{D(on)}$ = 10 mAdc, $V_{GS(off)}$ = 12 Vdc)	MPF970		—	3.5	8.0	
($I_{D(on)}$ = 1.5 mAdc, $V_{GS(off)}$ = 7.0 Vdc)	MPF971		—	5.0	10	
Turn-Off Time		t_{off}				ns
($I_{D(on)}$ = 10 mAdc, $V_{GS(off)}$ = 12 Vdc)	MPF970		—	13	25	
($I_{D(on)}$ = 1.5 mAdc, $V_{GS(off)}$ = 7.0 Vdc)	MPF971		—	88	120	

(1) Pulse Test: Pulse Width ≤ 100 μs, Duty Cycle ≤ 1.0%.

6

FIGURE 1 — EFFECT OF I_{DSS} ON DRAIN-SOURCE RESISTANCE AND GATE-SOURCE VOLTAGE

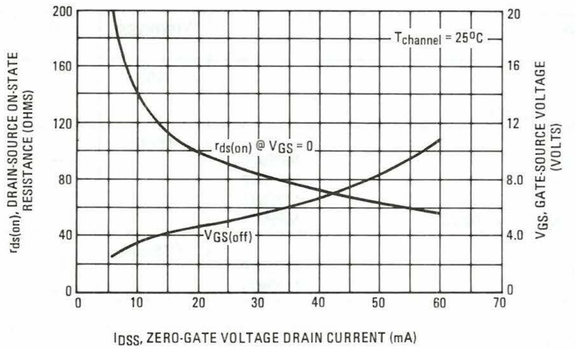


FIGURE 2 — TURN-ON DELAY TIME

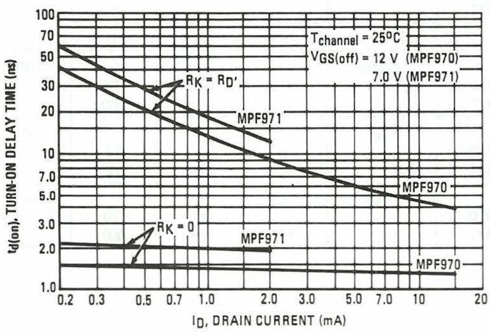


FIGURE 3 — RISE TIME

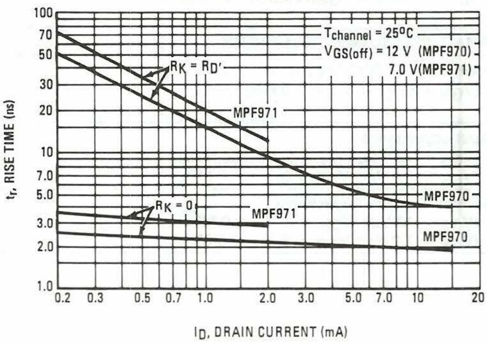


FIGURE 4 – TURN-OFF DELAY TIME

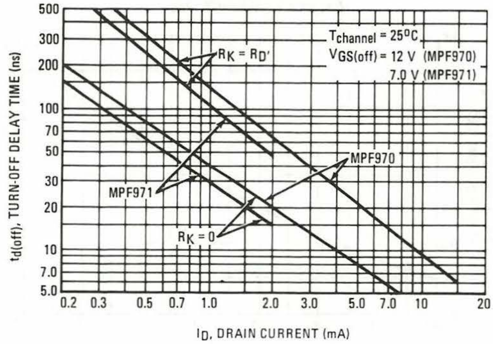


FIGURE 5 – FALL TIME

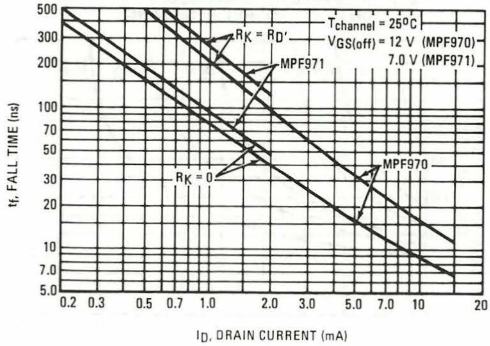
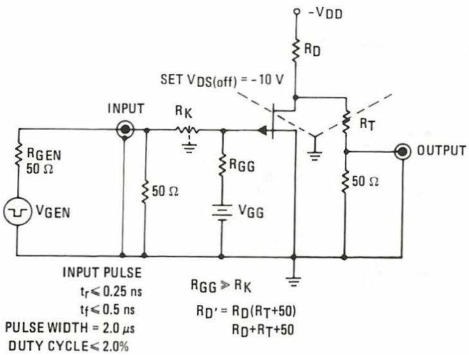


FIGURE 6 – SWITCHING TIME TEST CIRCUIT



NOTE 1

The switching characteristics shown above were measured using a test circuit similar to Figure 6. At the beginning of the switching interval, the gate voltage is at Gate Supply Voltage ($+V_{GG}$). The Drain-Source Voltage (V_{DS}) is slightly lower than Drain Supply Voltage (V_{DD}) due to the voltage divider. Thus Reverse Transfer Capacitance (C_{rss}) or Gate-Drain Capacitance (C_{gd}) is charged to $V_{GG} + V_{DS}$.

During the turn-on interval, Gate-Source Capacitance (C_{gs}) discharges through the series combination of R_{Gen} and R_K. C_{gd} must discharge to $V_{DS(on)}$ through R_G and R_K in series with the parallel combination of effective load impedance (R'_D) and Drain-Source Resistance (r_{ds}). During the turn-off, this charge flow is reversed.

Predicting turn-on time is somewhat difficult as the channel resistance r_{ds} is a function of the gate-source voltage. While C_{gs} discharges, V_{GS} approaches zero and r_{ds} decreases. Since C_{gd} discharges through r_{ds}, turn-on time is non-linear. During turn-off, the situation is reversed with r_{ds} increasing as C_{gd} charges.

The above switching curves show two impedance conditions; 1) R_K is equal to R_D, which simulates the switching behavior of cascaded stages where the driving source impedance is normally the load impedance of the previous stage, and 2) $R_K = 0$ (low impedance) the driving source impedance is that of the generator.

FIGURE 7 – TYPICAL FORWARD TRANSFER ADMITTANCE

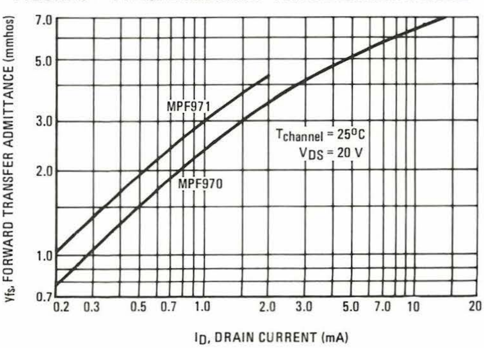


FIGURE 8 – TYPICAL CAPACITANCE

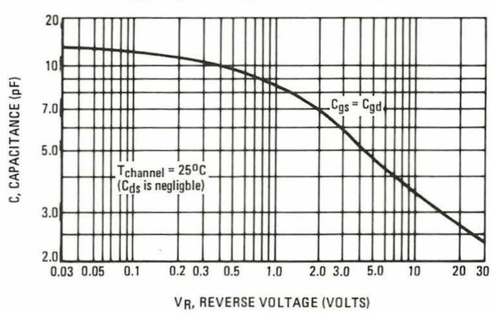


FIGURE 9 – EFFECT OF GATE-SOURCE VOLTAGE ON DRAIN-SOURCE RESISTANCE

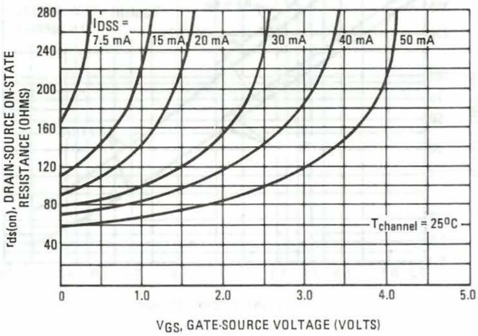
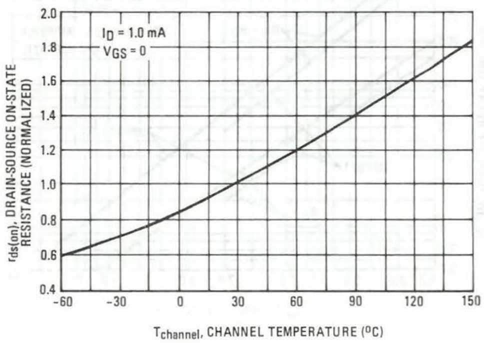
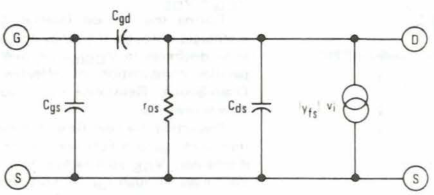


FIGURE 10 – EFFECT OF TEMPERATURE ON DRAIN-SOURCE ON-STATE RESISTANCE



6

FIGURE 11 – LOW FREQUENCY CIRCUIT MODEL



$y_{is} = j\omega C_{iss}$
$y_{os} = 1/r_{oss} + j\omega C_{oss}$
$y_{fs} = |y_{fs}|$
$y_{rs} = -j\omega C_{rss}$

$C_{iss} = C_{gd} + C_{gs}$
$C_{rss} = C_{gd}$
$C_{oss} = C_{gd} + C_{ds},\ C_{ds} \approx 0$

MPF2608
MPF2609

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
LOW-FREQUENCY, LOW NOISE
P-CHANNEL — DEPLETION

Refer to 2N5460 for graphs.

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Gate Current	I_G	50	mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	310 2.82	mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = 1.0\ \mu A$)		$V_{(BR)GSS}$	30	—	Vdc
Gate Reverse Current ($V_{GS} = 5.0$ Volts)		I_{GSS}	—	10	nA
Gate Source Cutoff Voltage ($V_{DS} = -5.0$ V, $I_D = -1.0\ \mu A$)		$V_{GS(off)}$	1.0	4.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current ($V_{DS} = -5.0$ Volts)	MPF2608 MPF2609	I_{DSS}*	−0.9 −2.0	−4.5 −10.0	mA
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance ($V_{DS} = -5.0$ Volts, f = 1.0 kHz)	MPF2608 MPF2609	$\lvert y_{fs} \rvert$*	1000 2500	— —	μmhos
Input Capacitance ($V_{DS} = -5.0$ Volts, $V_{GS} = 1.0$ V, f = 140 kHz)	MPF2608 MPF2609	C_{iss}	— —	17 30	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure ($V_{DS} = -5.0$ Volts, f = 1.0 kHz, R = 1.0 meg)		NF	—	3.0	dB

*Pulse Width ≤ 100 msec, Duty Cycle ≤ 10%.

MPF3330

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
LOW-FREQUENCY, LOW NOISE

P-CHANNEL — DEPLETION

Refer to 2N5460 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	20	Vdc
Gate-Source Voltage	V_{GS}	20	Vdc
Reverse Gate-Source Voltage	V_{GSR}	20	Vdc
Gate Current	I_G	10	mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	310 2.82	mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 10\ \mu A$)	$V_{(BR)GSS}$	20	—	Vdc
Gate Reverse Current ($V_{GS} = 10$ V)	I_{GSS}	—	10	nA
Gate Source Cutoff Voltage ($V_{DS} = -15$ V, $I_D = 10\ \mu A$)	$V_{GS(off)}$	—	6.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current ($V_{DS} = -10$ V)	I_{DSS}*	2.0	6.0	mA
Drain-Source Resistance ($I_D = 100\ \mu A$, $V_{GS} = 0$)	r_{DS}	—	800	Ω
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance ($V_{DS} = -10$ V, $I_D = 2.0$ mA, f = 1.0 kHz)	$\lvert y_{fs}\rvert$*	1500	3000	μmhos
Output Admittance ($V_{DS} = -10$ V, $I_D = 2.0$ mA, f = 1.0 kHz)	$\lvert y_{os}\rvert$	—	40	μmhos
Input Capacitance ($V_{DS} = -10$ Volts, $V_{GS} = 1.0$ Volt, f = 1.0 MHz)	C_{iss}	—	20	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure ($V_{DS} = -5.0$ V, $I_D = 1.0$ mA, $R_G = 1.0$ MΩ)	NF	—	3.0	dB

*Pulse Width ≤ 100 msec, Duty Cycle ≤ 10%.

MPF3821
MPF3822

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
GENERAL PURPOSE

N-CHANNEL — DEPLETION

Refer to 2N4220 for graphs.

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	50	Vdc
Drain-Gate Voltage	V_{DG}	50	Vdc
Gate-Source Voltage	V_{GS}	−50	Vdc
Drain Current	I_D	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.0	mW mW/°C
Junction Temperature Range	T_J	125	°C
Storage Temperature Range	T_{stg}	−65 to 150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = −1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	−50	—	Vdc
Gate Reverse Current (V_{GS} = −30 Vdc, V_{DS} = 0) (V_{GS} = −30 Vdc, V_{DS} = 0, T_A = 150°C)		I_{GSS}	 — —	 −0.1 −100	nAdc
Gate Source Cutoff Voltage (I_D = 0.5 nAdc, V_{DS} = 15 Vdc)	 MPF3821 MPF3822	$V_{GS(off)}$	 — —	 −4.0 −6.0	Vdc
Gate Source Voltage (I_D = 50 μAdc, V_{DS} = 15 Vdc) (I_D = 200 μAdc, V_{DS} = 15 Vdc)	 MPF3821 MPF3822	V_{GS}	 −0.5 −1.0	 −2.0 −4.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 15 Vdc, V_{GS} = 0)	 MPF3821 MPF3822	I_{DSS}	 0.5 2.0	 2.5 10	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)(1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	 MPF3821 MPF3822 MPF3821 MPF3822	$\|y_{fs}\|$	 1500 3000 1500 3000	 4500 6500 — —	μmhos
Output Admittance(1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	 MPF3821 MPF3822	$\|y_{os}\|$	 — —	 10 20	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	6.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	3.0	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_S = 1.0 megohm, f = 10 Hz, Noise Bandwidth = 5.0 Hz)		NF	—	5.0	dB
Equivalent Input Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, f = 10 Hz, Noise Bandwidth = 5.0 Hz)		e_n	—	200	nv/Hz$^{1/2}$

(1) Pulse Test: Pulse Width ≤ 100 ms, Duty Cycle ≤ 10%.

MPF3823
MPF3824

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
HIGH FREQUENCY
AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Drain-Source Voltage	MPF3823 MPF3824	V_{DS}	30 50	Vdc
Drain-Gate Voltage	MPF3823 MPF3824	V_{DG}	30 50	Vdc
Reverse Gate-Source Voltage	MPF3823 MPF3824	V_{GSR}	−30 −50	Vdc
Gate Current		I_G	10	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C		P_D	300 2.0	mW mW/°C
Lead Temperature		T_L	300	°C
Operating and Storage Junction Temperature Range		T_J, T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = −1.0 μA)	 MPF3823 MPF3824	$V_{(BR)GSS}$	 −30 −50	 — —	Vdc
Gate Leakage Current (V_{GS} = −20 V)		I_{GSS}	—	−0.5	nA
Gate Source Cutoff Voltage (V_{DS} = 15 V, I_D = 0.5 nA)		$V_{GS(off)}$	—	−8.0	Vdc
Gate Source Voltage (V_{GS} = 15 V, I_D = 400 μA)		V_{GS}	−1.0	−7.5	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (V_{DS} = 15 V)		I_{DSS}	4.0	20	mA
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 15 V, f = 1.0 kHz)		$\lvert y_{fs}\rvert$	3500	6500	μmhos
Output Admittance (V_{DS} = 15 V, f = 1.0 kHz)		$\lvert y_{os}\rvert$	—	35	μmhos
Input Capacitance (V_{DS} = 15 V, f = 1.0 MHz)		C_{iss}	—	6.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 V, f = 1.0 MHz)	 MPF3823 MPF3824	C_{rss}	 — —	 2.0 3.0	pF
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	 MPF3824 (Only)	$r_{ds(on)}$	—	250	Ohms
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DS} = 15 V, V_{GS} = 0, f = 100 MHz)	 MPF3823 (Only)	NF	—	2.5	dB

MPF3970
MPF3971
MPF3972

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
SWITCHING

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Reverse Gate-Source Voltage	V_{GSR}	−40	Vdc
Forward Gate Current	I_{GF}	50	mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	310 2.82	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = 1.0\ \mu A$, $V_{GS} = 0$)		$V_{(BR)GSS}$	40	—	Vdc
Drain to Gate Leakage ($V_{DG} = 20$ V, $I_S = 0$)		I_{DGO}	—	250	pA
Gate Reverse Current ($V_{GS} = 20$ V, $V_{DS} = 0$)		I_{GSS}	—	250	pA
Gate Source Cutoff Voltage ($V_{DS} = -20$ V, $I_D = 1.0$ nA)	MPF3970 MPF3971 MPF3972	$V_{GS(off)}$	−4.0 −2.0 −0.5	−10.0 −5.0 −3.0	Vdc
Drain Source Voltage ($V_{GS} = 0$) ($I_D = 20$ mA) ($I_D = 10$ mA) ($I_D = 5.0$ mA)	MPF3970 MPF3971 MPF3972	V_{GS}	— — —	1.0 1.5 2.0	Vdc
Drain Cutoff Current ($V_{DS} = 20$ V, $V_{GS} = -12$ V)		$I_{D(off)}$	—	250	pA
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current ($V_{DS} = 20$ V, $V_{GS} = 0$)	MPF3970 MPF3971 MPF3972	I_{DSS}	50 25 5.0	150 75 30	mA
Drain-Source "ON" Resistance ($I_D = 1.0$ mA, $V_{GS} = 0$)	MPF3970 MPF3971 MPF3972	$r_{DS(on)}$	— — —	30 60 100	Ω
Input Capacitance ($V_{DS} = 20$ V, $V_{GS} = 0$, f = 1.0 MHz)		C_{iss}	—	25	pF
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = -12$ V, f = 1.0 MHz)		C_{rss}	—	6.0	pF
FUNCTIONAL CHARACTERISTICS					
Drain-Gate Leakage ($V_{DG} = 20$ V, $I_S = 0$, $T_A = 150°C$)		I_{DGO}	—	500	nA
Drain Cutoff Current ($V_{DS} = 20$ V, $V_{GS} = -12$ V, $T_A = 150°C$)		$I_{D(off)}$	—	500	nA

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
Drain-Source "ON" Resistance (I_D = 0, V_{GS} = 0, f = 1.0 kHz)	MPF3970 MPF3971 MPF3972	$r_{ds(on)}$	— — —	30 60 100	Ω
SWITCHING CHARACTERISTICS					
Switching Characteristics (MPF3970 Only) (V_{DD} = 10 V, V_{GS} = 0, $I_{D(on)}$ = 20 mA, $V_{GS(off)}$ = 10 V)		$t_{d(on)}$ t_r t_{off}	— — —	10 10 30	nsec nsec nsec
Switching Characteristics (MPF3971 Only) (V_{DD} = 10 V, V_{GS} = 0, $I_{D(on)}$ = 10 mA, $V_{GS(off)}$ = 5.0 V)		$t_{d(on)}$ t_r t_{off}	— — —	15 15 60	nsec nsec nsec
Switching Characteristics (MPF3972 Only) (V_{DD} = 10 V, V_{GS} = 0, $I_{D(on)}$ = 5.0 mA, $V_{GS(off)}$ = 3.0 V)		$t_{d(on)}$ t_r t_{off}	— — —	40 40 100	nsec nsec nsec

6

MPF4093

CASE 29-03, STYLE 5
TO-92 (TO-226AA)

JFET
SWITCHING

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Gate-Source Voltage	V_{GS}	−40	Vdc
Gate Current	I_G	10	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 3.0	mW mW/°C
Lead Temperature (1/16″ from Case for 10 Seconds)	T_L	300	°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 1.0 μA, V_{DS} = 0)	$V_{(BR)GSS}$	−40	—	Vdc
Gate Reverse Current (V_{DG} = −20 V, I_S = 0)	I_{DGO}	—	1.0	nA
Drain-Gate Leakage (V_{DG} = −20 V, I_S = 0, T_A = 150°C)	I_{DGO}	—	400	nA
Drain Cutoff Current (V_{DS} = 20 V, V_{GS} = −6.0 V)	$I_{D(off)}$	—	1.0	nA
Drain-Gate "OFF" Current (V_{DS} = 20 V, V_{GS} = −6.0 V, T_A = 150°C)	$I_{D(off)}$	—	400	nA
Gate 1 to Source Cutoff Voltage (V_{DS} = 20 V, I_D = 1.0 nA)	$V_{G1S(off)}$	−1.0	−5.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (V_{DS} = 20 V, V_{GS} = 0)	I_{DSS}	8.0	—	mA
Drain-Source On-Voltage (V_{GS} = 0, I_D = 2.5 mA)	$V_{DS(on)}$	—	0.2	Vdc
Static Drain-Source On Resistance (V_{GS} = 0, I_D = 1.0 mA) (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	$r_{DS(on)}$	 — —	 80 80	Ω
SMALL-SIGNAL CHARACTERISTICS				
Input Capacitance (V_{DS} = 20 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	16	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = −20 V, f = 1.0 MHz)	C_{rss}	—	5.0	pF
SWITCHING CHARACTERISTICS				
Delay Time	t_d	—	20	ns
Rise Time	t_r	—	40	ns
Turn-Off Time	t_{off}	—	80	ns

MPF4117,A
MPF4118,A
MPF4119,A

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
DC AMPLIFIER TRANSISTOR

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	−40	Vdc
Drain-Gate Voltage	V_{DG}	−40	Vdc
Gate Current	I_G	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Storage Channel Temperature Range	T_{stg}	−65 to +125	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (V_{DS} = 0, I_G = −1.0 μAdc)		$V_{(BR)GSS}$	−40	—	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0)	MPF4117, 4118, 4119 MPF4117A, 4118A, 4119A	I_{GSS}	— —	−10 −1.0	pAdc
(V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 125°C)	MPF4117, 4118, 4119 MPF4117A, 4118A, 4119A		— —	−25 −2.5	nAdc
Gate Source Cutoff Voltage (V_{DS} = 10 Vdc, I_D = 1.0 nAdc)	MPF4117,A MPF4118,A MPF4119,A	$V_{GS(off)}$	−0.6 −1.0 −2.0	−1.8 −3.0 −6.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 10 Vdc, V_{GS} = 0)	MPF4117,A MPF4118,A MPF4119,A	I_{DSS}	0.03 0.08 0.20	0.09 0.24 0.60	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Input Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	—	3.0	pF
Reverse Transfer Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	1.5	pF
Common-Source Forward Transconductance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 kHz)	MPF4117,A MPF4118,A MPF4119,A	g_{fs}	70 80 100	210 250 330	μmhos
Common-Source Output Conductance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 kHz)	MPF4117,A MPF4118,A MPF4119,A	g_{os}	— — —	3.0 5.0 10	μmhos

(1) I_{DSS} is measured during a 2.0 ms interval 100 ms after power is applied.

FIGURE 1 — TRANSFER CHARACTERISTICS

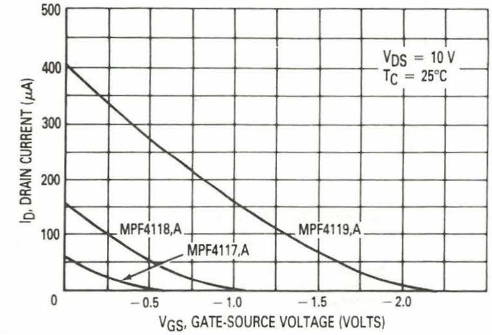


FIGURE 2 — TRANSCONDUCTANCE CHARACTERISTICS

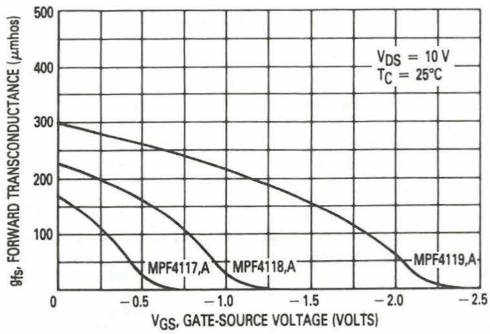
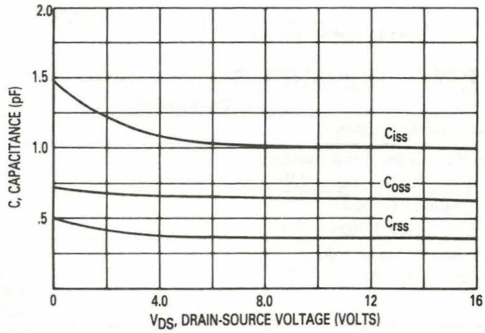


FIGURE 3 — CAPACITANCE versus DRAIN-SOURCE VOLTAGE



6

MPF4220,A
MPF4221,A
MPF4222,A

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
LOW-FREQUENCY

N-CHANNEL — DEPLETION

Refer to 2N4220 for graphs.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	30	Vdc
Gate Current	I_G	10	mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	310 2.82	mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

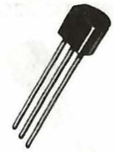
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = -10\ \mu A$, $V_{DS} = 0$ V)		$V_{(BR)GSS}$	−30	—	Vdc
Gate Reverse Current ($V_{GS} = -15$ V, $V_{DS} = 0$ V)		I_{GSS}	—	−100	pA
Gate Source Cutoff Voltage ($V_{DS} = 15$ V, $I_D = 0.1$ nA)	 MPF4220,A MPF4221,A MPF4222,A	$V_{GS(off)}$	 — — —	 −4.0 −6.0 −8.0	Vdc
Gate Source Voltage ($V_{DS} = 15$ V, $I_D = 50\ \mu A$) ($V_{DS} = 15$ V, $I_D = 200\ \mu A$) ($V_{DS} = 15$ V, $I_D = 500\ \mu A$)	 MPF4220,A MPF4221,A MPF4222,A	V_{GS}	 −0.5 −1.0 −2.0	 −2.5 −5.0 −6.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current ($V_{DS} = 15$ Volts, $V_{GS} = 0$ V)	 MPF4220,A MPF4221,A MPF4222,A	I_{DSS}*	 +0.5 +2.0 +5.0	 +3.0 +6.0 +15.0	mA
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance ($V_{DS} = 15$ V, f = 1.0 kHz, $V_{GS} = 0$ V)	 MPF4220,A MPF4221,A MPF4222,A	$\|y_{fs}\|$*	 1000 2000 2500	 4000 5000 6000	μmhos
Output Admittance ($V_{DS} = 15$ V, f = 1.0 kHz, $V_{GS} = 0$ V)	 MPF4220,A MPF4221,A MPF4222,A	$\|y_{os}\|$	 — — —	 10 20 40	μmhos
Input Capacitance ($V_{DS} = 15$ V, f = 1.0 MHz)		C_{iss}	—	6.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ V, f = 1.0 MHz)		C_{rss}	—	2.0	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure ($V_{DS} = 15$ V, f = 100 Hz, $R_G = 1.0$ MΩ)	 MPF4220,A MPF4221,A MPF4222,A	NF	—	2.5	dB

*Pulse Width ≤ 100 msec, Duty Cycle ≤ 10%.

MPF4223
MPF4224

CASE 29-02, STYLE 5
TO-92 (TO-226AA)



JFET
HIGH-FREQUENCY
AMPLIFIER

N-CHANNEL — DEPLETION

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Drain Current	I_D	20	mA
Gate Current	I_G	10	mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 2.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = -10\ \mu A$)		$V_{(BR)GSS}$	−30	—	Vdc
Gate 1 Leakage Current ($V_{G1S} = -20$ V)	MPF4223 MPF4224	I_{G1SS}	— —	0.25 0.50	nA
Gate Source Cutoff Voltage ($I_D = 0.25$ nA, $V_{DS} = 15$ V) ($I_D = 0.5$ nA, $V_{DS} = 15$ V)	MPF4223 MPF4224	$V_{GS(off)}$	−0.1 −0.1	−8.0 −8.0	Vdc
Gate Source Voltage ($I_D = 0.3$ mA, $V_{DS} = 15$ V) ($I_D = 0.2$ mA, $V_{DS} = 15$ V)	MPF4223 MPF4224	V_{GS}	−1.0 −1.0	−7.0 −7.5	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current ($V_{DS} = 15$ V)	MPF4223 MPF4224	I_{DSS}	3.0 2.0	18 20	mA
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance ($V_{DS} = 15$ V, $V_{GS} = 0$ V, f = 1.0 kHz)	MPF4223 MPF4224	$\|y_{fs}\|$	3000 2000	7000 7500	μmhos
Output Conductance ($V_{DS} = 15$ V, $V_{GS} = 0$ V, f = 200 MHz)		$Re(y_{os})$	—	200	μmhos
Input Capacitance ($V_{DS} = 15$ V, $V_{GS} = 0$ V, f = 1.0 MHz)		C_{iss}	—	6.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ V, $V_{GS} = 0$ V, f = 1.0 MHz)		C_{rss}	—	2.0	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure ($V_{DS} = 15$ V, $V_{GS} = 0$ V, $R_G = 1.0$ kΩ, f = 200 MHz)	MPF4223 (Only)	NF	—	5.0	dB
Common Source Power Gain ($V_{DS} = 15$ V, $V_{GS} = 0$ V, f = 200 MHz)	MPF4223 (Only)	G_{ps}	10	—	dB

MPF4391
MPF4392
MPF4393

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
SWITCHING

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Forward Gate Current	$I_{G(f)}$	50	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	625 5.0	mW mW/°C
Operating and Storage Channel Temperature Range	$T_{channel}$, T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	—	—	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0) (V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 100°C)		I_{GSS}	 — —	 — —	 1.0 0.2	 nAdc μAdc
Drain-Cutoff Current (V_{DS} = 15 Vdc, V_{GS} = 12 Vdc) (V_{DS} = 15 Vdc, V_{GS} = 12 Vdc, T_A = 100°C)		$I_{D(off)}$	 — —	 — —	 1.0 0.1	 nAdc μAdc
Gate Source Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	 MPF4391 MPF4392 MPF4393	V_{GS}	 4.0 2.0 0.5	 — — —	 10 5.0 3.0	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 15 Vdc, V_{GS} = 0)	 MPF4391 MPF4392 MPF4393	I_{DSS}	 60 25 5.0	 — — —	 130 75 30	mAdc
Drain-Source On-Voltage (I_D = 12 mAdc, V_{GS} = 0) (I_D = 6.0 mAdc, V_{GS} = 0) (I_D = 3.0 mAdc, V_{GS} = 0)	 MPF4391 MPF4392 MPF4393	$V_{DS(on)}$	 — — —	 — — —	 0.4 0.4 0.4	Vdc
Static Drain-Source On Resistance (I_D = 1.0 mAdc, V_{GS} = 0)	 MPF4391 MPF4392 MPF4393	$r_{DS(on)}$	 — — —	 — — —	 30 60 100	Ohms
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = 15 Vdc, I_D = 60 mAdc, f = 1.0 kHz) (V_{DS} = 15 Vdc, I_D = 25 mAdc, f = 1.0 kHz) (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 1.0 kHz)	 MPF4391 MPF4392 MPF4393	$\|y_{fs}\|$	 — — —	 20 17 12	 — — —	mmhos
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	MPF4391 MPF4392 MPF4393	$r_{ds(on)}$	— — —	— — —	30 60 100	Ohms
Input Capacitance (V_{GS} = 15 Vdc, V_{DS} = 0, f = 1.0 MHz)		C_{iss}	—	6.0	10	pF

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Reverse Transfer Capacitance		C_{rss}				pF
(V_{GS} = 12 Vdc, V_{DS} = 0, f = 1.0 MHz)			—	2.5	3.5	
(V_{DS} = 15 Vdc, I_D = 10 mAdc, f = 1.0 MHz)			—	3.2	—	
SWITCHING CHARACTERISTICS						
Rise Time (See Figure 2)		t_r				ns
($I_{D(on)}$ = 12 mAdc)	MPF4391		—	1.2	5.0	
($I_{D(on)}$ = 6.0 mAdc)	MPF4392		—	2.0	5.0	
($I_{D(on)}$ = 3.0 mAdc)	MPF4393		—	2.5	5.0	
Fall Time (See Figure 4)		t_f				ns
($V_{GS(off)}$ = 12 Vdc)	MPF4391		—	7.0	15	
($V_{GS(off)}$ = 7.0 Vdc)	MPF4392		—	15	20	
($V_{GS(off)}$ = 5.0 Vdc)	MPF4393		—	29	35	
Turn-On Time (See Figures 1 and 2)		t_{on}				ns
($I_{D(on)}$ = 12 mAdc)	MPF4391		—	3.0	15	
($I_{D(on)}$ = 6.0 mAdc)	MPF4392		—	4.0	15	
($I_{D(on)}$ = 3.0 mAdc)	MPF4393		—	6.5	15	
Turn-Off Time (See Figures 3 and 4)		t_{off}				ns
($V_{GS(off)}$ = 12 Vdc)	MPF4391		—	10	20	
($V_{GS(off)}$ = 7.0 Vdc)	MPF4392		—	20	35	
($V_{GS(off)}$ = 5.0 Vdc)	MPF4393		—	37	55	

(1) Pulse Test: Pulse Width ≤ 100 μs, Duty Cycle ≤ 1.0%.

6

TYPICAL SWITCHING CHARACTERISTICS

FIGURE 1 — TURN-ON DELAY TIME

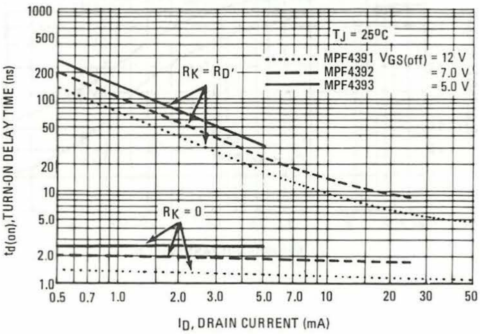


FIGURE 2 — RISE TIME

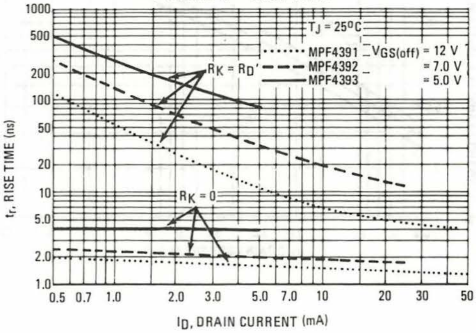


FIGURE 3 — TURN-OFF DELAY TIME

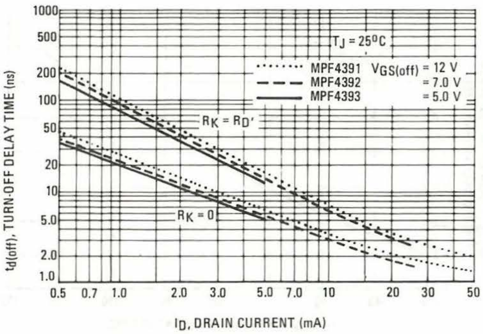


FIGURE 4 — FALL TIME

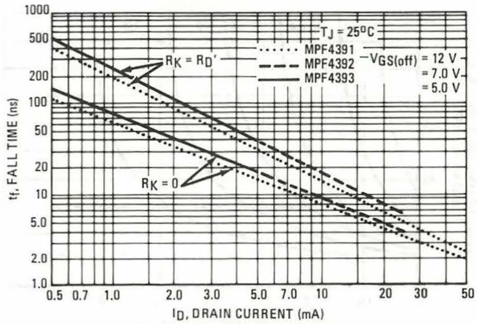
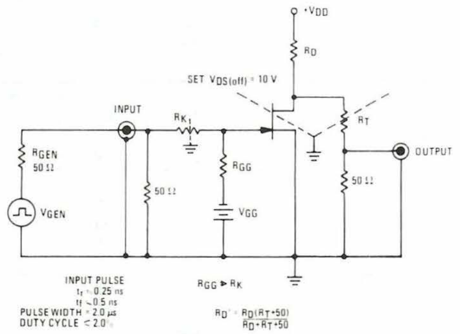


FIGURE 5 – SWITCHING TIME TEST CIRCUIT



NOTE 1

The switching characteristics shown above were measured using a test circuit similar to Figure 5. At the beginning of the switching interval, the gate voltage is at Gate Supply Voltage ($-V_{GG}$). The Drain-Source Voltage (V_{DS}) is slightly lower than Drain Supply, Voltage (V_{DD}) due to the voltage divider. Thus Reverse Transfer Capacitance (C_{rss}) or Gate-Drain Capacitance (C_{gd}) is charged to $V_{GG} + V_{DS}$.

During the turn-on interval, Gate-Source Capacitance (C_{gs}) discharges through the series combination of R_{Gen} and R_K. C_{gd} must discharge to $V_{DS(on)}$ through R_G and R_K in series with the parallel combination of effective load impedance (R'_D) and Drain-Source Resistance (r_{ds}). During the turn-off, this charge flow is reversed.

Predicting turn-on time is somewhat difficult as the channel resistance r_{ds} is a function of the gate-source voltage. While C_{gs} discharges, V_{GS} approaches zero and r_{ds} decreases. Since C_{gd} discharges through r_{ds}, turn-on time is non-linear. During turn-off, the situation is reversed with r_{ds} increasing as C_{gd} charges.

The above switching curves show two impedance conditions; 1) R_K is equal to $R_{D'}$ which simulates the switching behavior of cascaded stages where the driving source impedance is normally the load impedance of the previous stage, and 2) $R_K = 0$ (low impedance) the driving source impedance is that of the generator.

6

FIGURE 6 – TYPICAL FORWARD TRANSFER ADMITTANCE

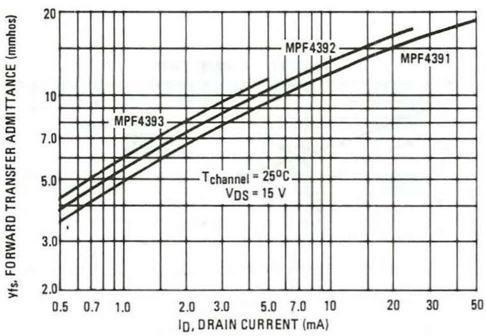


FIGURE 7 – TYPICAL CAPACITANCE

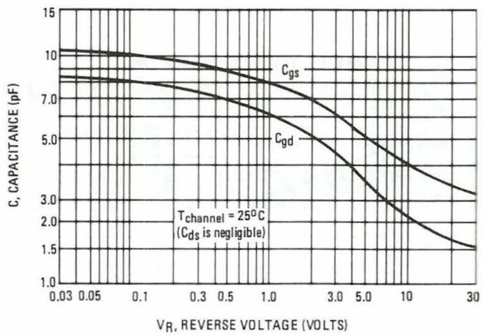


FIGURE 8 – EFFECT OF GATE-SOURCE VOLTAGE ON DRAIN-SOURCE RESISTANCE

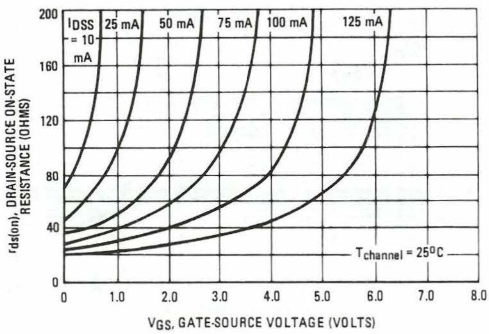


FIGURE 9 – EFFECT OF TEMPERATURE ON DRAIN–SOURCE ON-STATE RESISTANCE

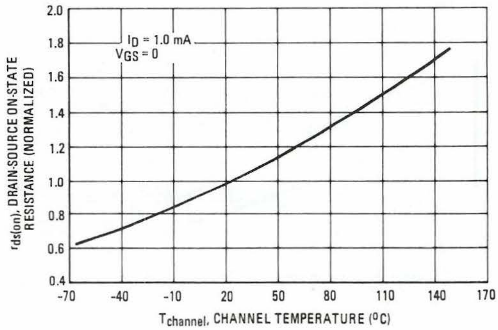
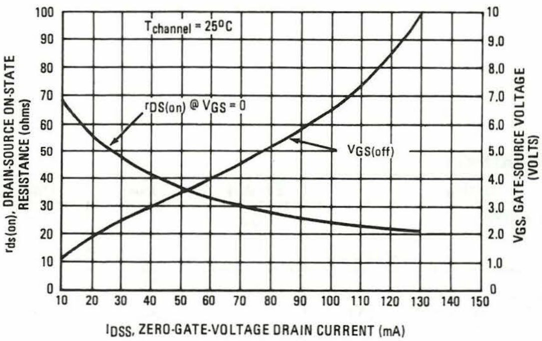


FIGURE 10 — EFFECT OF IDSS ON DRAIN-SOURCE RESISTANCE AND GATE-SOURCE VOLTAGE



NOTE 2

The Zero-Gate-Voltage Drain Current (I_{DSS}), is the principle determinant of other J-FET characteristics. Figure 10 shows the relationship of Gate-Source Off Voltage ($V_{GS(off)}$) and Drain-Source On Resistance ($r_{ds(on)}$) to I_{DSS}. Most of the devices will be within ±10% of the values shown in Figure 10. This data will be useful in predicting the characteristic variations for a given part number.

For example:

Unknown

$r_{ds(on)}$ and V_{GS} range for an MPF4392

The electrical characteristics table indicates that an MPF4392 has an I_{DSS} range of 25 to 75 mA. Figure 10, shows $r_{ds(on)}$ = 52 Ohms for I_{DSS} = 25 mA and 30 Ohms for I_{DSS} = 75 mA. The corresponding V_{GS} values are 2.2 volts and 4.8 volts.

6

MPF4416,A

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET
HIGH-FREQUENCY
AMPLIFIER

N-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Gate-Source Voltage MPF4416 MPF4416A	V_{GS}	 −30 −35	Vdc
Gate Current	I_G	10	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.7	mW mW/°C
Lead Temperature	T_L	300	°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = −1.0 μA) MPF4416 MPF4416A	$V_{(BR)GSS}$	 −30 −35	 — —	Vdc
Gate Reverse Current (V_{GS} = −20 V)	I_{GSS}	—	−250	pA
Gate Source Cutoff Voltage (V_{DS} = 15 V, I_D = 1.0 nA) MPF4416 MPF4416A	$V_{GS(off)}$	 — −2.5	 −6.0 −6.0	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current* (V_{DS} = 15 V)	I_{DSS}	5.0	15	mA
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 15 V, f = 1.0 kHz)	$\|y_{fs}\|$	4500	7500	μmhos
Input Admittance (V_{DS} = 15 V, f = 100 MHz) (V_{DS} = 15 V, f = 400 MHz)	$Re(y_{is})$	 — —	 100 1000	μmhos
Output Admittance (V_{DS} = 15 V, f = 1.0 kHz)	$\|y_{os}\|$	—	50	μmhos
Output Conductance (V_{DS} = 15 V, f = 100 MHz) (V_{DS} = 15 V, f = 400 MHz)	$Re(y_{os})$	 — —	 75 100	μmhos
Forward Transconductance* (V_{DS} = 15 V, f = 400 MHz)	$Re(y_{fs})$	4000	—	μmhos
Input Capacitance (V_{DS} = 15 V, f = 1.0 MHz)	C_{iss}	—	4.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 V, f = 1.0 MHz)	C_{rss}	—	0.8	pF
Output Capacitance (V_{DS} = 15 V, f = 1.0 MHz)	C_{oss}	—	2.0	pF
FUNCTIONAL CHARACTERISTICS				
Noise Figure (V_{DS} = 15 V, I_D = 5.0 mA, R_G = 1.0 kΩ, f = 100 MHz) (V_{DS} = 15 V, I_D = 5.0 mA, R_G = 1.0 kΩ, f = 400 MHz)	NF	 — —	 2.0 4.0	dB
Common Source Power Gain (V_{DS} = 15 V, I_D = 5.0 mA, f = 100 MHz) (V_{DS} = 15 V, I_D = 5.0 mA, f = 400 MHz)	G_{ps}	 18 10	 — —	dB

*Pulse Test Duration = 2.0 msec.

MPF4856,A thru MPF4861,A

CASE 29-02, STYLE 5
TO-92 (TO-226AA)

JFET SWITCHING

N-CHANNEL — DEPLETION

Refer to 2N4856 for graphs.

MAXIMUM RATINGS

Rating	Symbol	MPF4856,A MPF4857,A MPF4858,A	MPF4859,A MPF4860,A MPF4861,A	Unit
Drain-Source Voltage	V_{DS}	+40	+30	Vdc
Drain-Gate Voltage	V_{DG}	+40	+30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	−40	−30	Vdc
Forward Gate Current	I_{GF}	50		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.4		mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +150		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0) MPF4856,A, MPF4857,A, MPF4858,A MPF4859,A, MPF4860,A, MPF4861,A	$V_{(BR)GSS}$	 −40 −30	 — —	Vdc
Gate Reverse Current (V_{GS} = −20 Vdc, V_{DS} = 0) MPF4856,A, MPF4857,A, MPF4858,A (V_{GS} = −15 Vdc, V_{DS} = 0) MPF4859,A, MPF4860,A, MPF4861,A (V_{GS} = −20 Vdc, V_{DS} = 0, T_A = 150°C) MPF4856,A, MPF4857,A, MPF4858,A (V_{GS} = −15 Vdc, V_{DS} = 0, T_A = 150°C) MPF4859,A, MPF4860,A, MPF4861,A	I_{GSS}	 — — — —	 0.25 0.25 0.5 0.5	 nAdc μAdc
Gate Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 0.5 nAdc) MPF4856,A, MPF4859,A MPF4857,A, MPF4860,A MPF4858,A, MPF4861,A	$V_{GS(off)}$	 −4.0 −2.0 −0.8	 −10 −6.0 −4.0	Vdc
Drain Cutoff Current (V_{DS} = 15 Vdc, V_{GS} = −10 Vdc) (V_{DS} = 15 Vdc, V_{GS} = −10 Vdc, T_A = 150°C)	$I_{D(off)}$	 — —	 0.25 0.5	 nAdc μAdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 15 Vdc, V_{GS} = 0) MPF4856,A, MPF4859,A MPF4857,A, MPF4860,A MPF4858,A, MPF4861,A	I_{DSS}	 50 20 8.0	 — 100 80	mAdc
Drain-Source On-Voltage (I_D = 20 mAdc, V_{GS} = 0) MPF4856,A, MPF4859,A (I_D = 10 mAdc, V_{GS} = 0) MPF4857,A, MPF4860,A (I_D = 5.0 mAdc, V_{GS} = 0) MPF4858,A, MPF4861,A	$V_{DS(on)}$	 — — —	 0.75 0.5 0.5	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz) MPF4856,A, MPF4859,A MPF4857,A, MPF4860,A MPF4858,A, MPF4861,A	$r_{ds(on)}$	 — — —	 25 40 60	Ohms
Input Capacitance (V_{DS} = 0, V_{GS} = −10 Vdc, f = 1.0 MHz) MPF4856 thru MPF4861 MPF4856A thru MPF4861A	C_{iss}	 — —	 18 10	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = −10 Vdc, f = 1.0 MHz) MPF4856 thru MPF4861 MPF4856A, MPF4859A MPF4857A, MPF4858A, MPF4860A, MPF4861A	C_{rss}	 — — —	 8.0 4.0 3.5	pF

6

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic			Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS						
Turn-On Delay Time	Conditions for MPF4856,A, MPF4859,A:	MPF4856, MPF4859	$t_{d(on)}$	—	6.0	ns
		MPF4856A, MPF4859A		—	5.0	
	(V_{DD} = 10 Vdc, $I_{D(on)}$ = 20 mAdc,	MPF4857, MPF4860		—	6.0	
	$V_{GS(on)}$ = 0, $V_{GS(off)}$ = −10 Vdc)	MPF4857A, MPF4860A		—	6.0	
		MPF4858, MPF4861		—	10	
		MPF4858A, MPF4861A		—	8.0	
Rise Time	Conditions for MPF4857,A, MPF4860,A:	MPF4856,A, MPF4859,A	t_r	—	3.0	ns
		MPF4857,A, MPF4860,A		—	4.0	
	(V_{DD} = 10 Vdc, $I_{D(on)}$ = 10 mAdc,	MPF4858, MPF4861		—	10	
	$V_{GS(on)}$ = 0, $V_{GS(off)}$ = −6.0 Vdc)	MPF4858A, MPF4861A		—	8.0	
Turn-Off Time		MPF4856, MPF4859	t_{off}	—	25	ns
	Conditions for MPF4858,A, MPF4861,A:	MPF4856A, MPF4859A		—	20	
		MPF4857, MPF4860		—	50	
	(V_{DD} = 10 Vdc, $I_{D(on)}$ = 5.0 mAdc,	MPF4857A, MPF4860A		—	40	
	$V_{GS(on)}$ = 0, $V_{GS(off)}$ = −4.0 Vdc)	MPF4858, MPF4861		—	100	
		MPF4858A; MPF4861A		—	80	

(1) Pulse Test: Pulse Width = 100 ms, Duty Cycle ≤ 10%.
(2) The $I_{D(on)}$ values are nominal; exact values vary slightly with transistor parameters.

6

U308
U309
U310

CASE 27-02, STYLE 4
TO-52 (TO-206AC)

JFET
VHF/UHF AMPLIFIER

N-CHANNEL — DEPLETION

6

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Gate Current	I_G	20	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 4.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150	°C

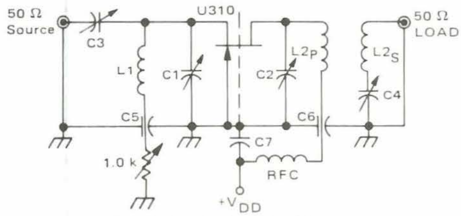
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = 1.0 μA, V_{DS} = 0)		$V_{(BR)GSS}$	−25	—	—	V
Gate Reverse Current		I_{GSS}				
(V_{GS} = −15 V)			—	—	−150	pA
(V_{GS} = 0, T_A = 125°C)			—	—	−150	nA
Gate Source Cutoff Voltage (V_{DS} = 10 V, I_D = 1.0 nA)	U308	$V_{GS(off)}$	−1.0	—	−6.0	V
	U309		−1.0	—	−4.0	
	U310		−2.5	—	−6.0	
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 10 V, V_{GS} = 0)	U308	I_{DSS}	12	—	60	mA
	U309		12	—	30	
	U310		24	—	60	
Gate-Source Forward Voltage (I_G = 10 mA, V_{DS} = 0)		$V_{GS(f)}$	—	—	1.0	V
SWITCHING CHARACTERISTICS						
Common-Gate Forward Transconductance(1) (V_{DS} = 10 V, I_D = 10 mA, f = 1.0 kHz)	U308	g_{fg}	10	—	20	mmhos
	U309		10	—	20	
	U310		10	—	18	
Common-Gate Output Conductance (V_{DS} = 10 V, I_D = 10 mA, f = 1.0 kHz)		g_{og}	—	150	—	μmhos
Drain-Gate Capacitance (V_{GS} = −10 V, V_{DS} = 10 V, f = 1.0 MHz)		C_{gd}	—	—	2.5	pF
Gate-Source Capacitance (V_{GS} = −10 V, V_{DS} = 10 V, f = 1.0 MHz)		C_{gs}	—	—	5.0	pF
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 10 V, I_D = 10 mA, f = 100 Hz)		$\overline{e}_n$	—	10	—	$nV/\sqrt{Hz}$

(1) Pulse test duration = 2.0 ms.
(2) See Figures 10 and 11 for Noise Figure and Power Gain information.

6

FIGURE 1 – 450 MHz COMMON-GATE AMPLIFIER TEST CIRCUIT



C1 = C2 = 0.8 – 10 pF, JFD #MVM010W.
C3 = C4 = 8-35 pF Erie #539-002D.
C5 = C6 = 5000 pF Erie (2443-000).
C7 = 1000 pF, Allen Bradley #FA5C.
RFC = 0.33 μH Miller #9230-30.
L1 = One Turn #16 Cu, 1/4'' I.D. (Air Core).
$L2_P$ = One Turn #16 Cu, 1/4'' I.D. (Air Core).
$L2_S$ = One Turn #16 Cu, 1/4'' I.D. (Air Core).

FIGURE 2 – DRAIN CURRENT and TRANSFER CHARACTERISTICS versus GATE-SOURCE VOLTAGE

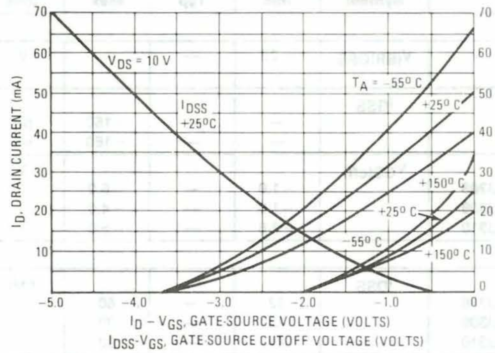


FIGURE 3 – FORWARD TRANSCONDUCTANCE versus GATE-SOURCE VOLTAGE

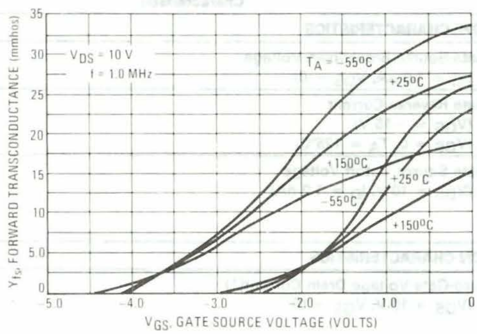


FIGURE 4 – COMMON-SOURCE OUTPUT ADMITTANCE and FORWARD TRANSCONDUCTANCE versus DRAIN CURRENT

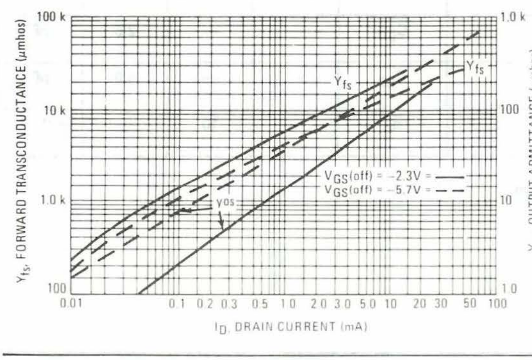


FIGURE 5 – ON RESISTANCE and JUNCTION CAPACITANCE versus GATE-SOURCE VOLTAGE

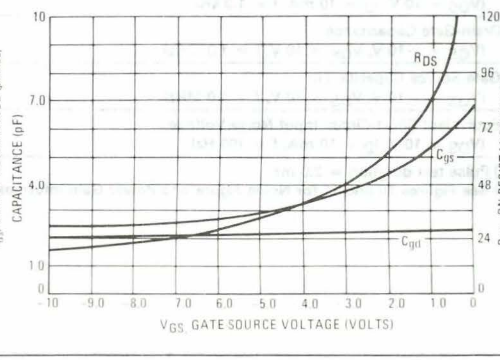


FIGURE 6 – COMMON-GATE Y PARAMETER MAGNITUDE versus FREQUENCY

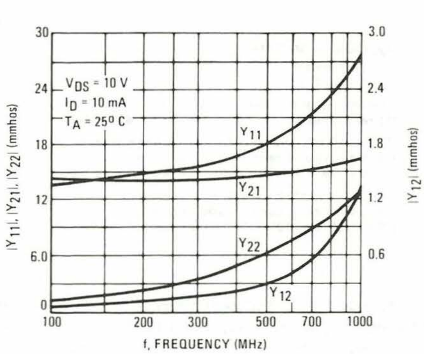


FIGURE 7 – COMMON-GATE S PARAMETER MAGNITUDE versus FREQUENCY

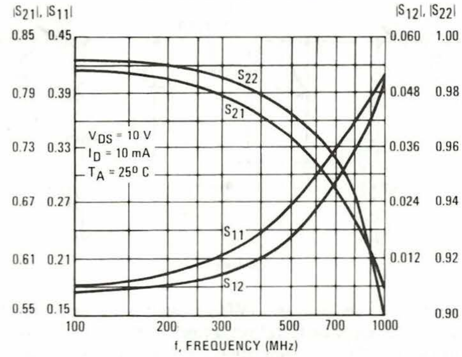


FIGURE 8 – COMMON-GATE Y PARAMETER PHASE-ANGLE versus FREQUENCY

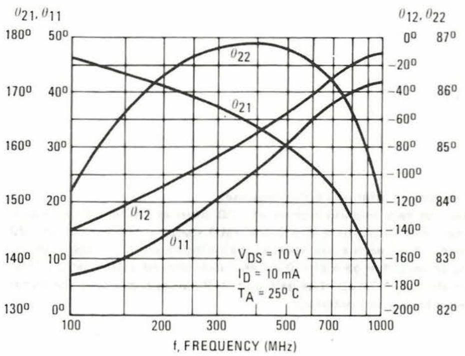


FIGURE 9 – S PARAMETER PHASE-ANGLE versus FREQUENCY

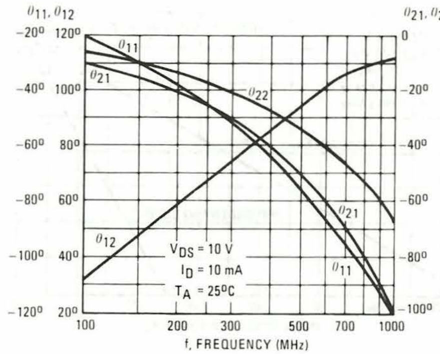


FIGURE 10 – NOISE FIGURE and POWER GAIN versus DRAIN CURRENT

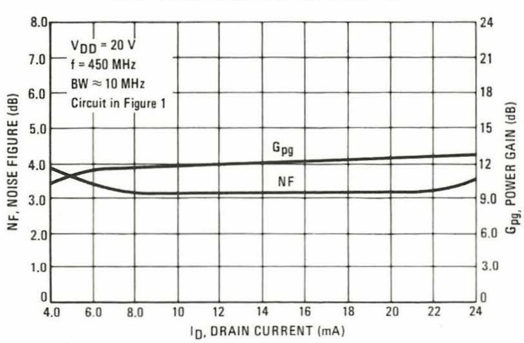


FIGURE 11 – NOISE FIGURE and POWER GAIN versus FREQUENCY

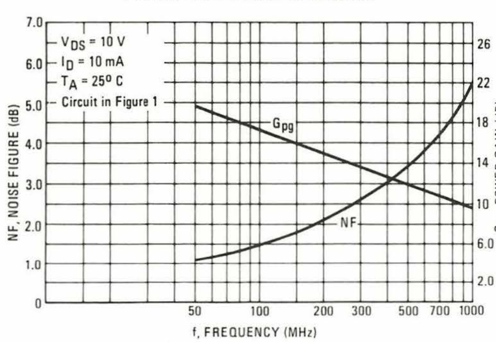
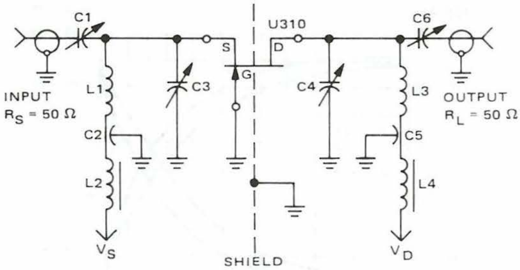


FIGURE 12 – 450 MHz IMD EVALUATION AMPLIFIER



B_W (3dB) – 36.5 MHz
I_D – 10 mAdc
V_{DS} – 20 Vdc
Device case grounded
IM test tones – f1 = 449.5 MHz, f2 = 450.5 MHz

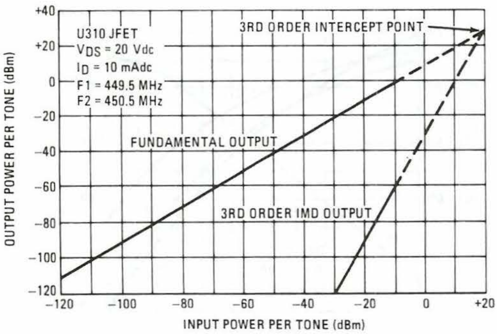
C1 = 1-10 pf Johanson Air variable trimmer.
C2, C5 = 100 pf feed thru button capacitor.
C3, C4, C6 = 0.5-6 pf Johanson Air variable trimmer.

L1 = 1/8" x 1/32" x 1-5/8" copper bar
L2, L4 = Ferroxcube Vk200 choke.
L3 = 1/8" x 1/32" x 1-7/8" copper bar.

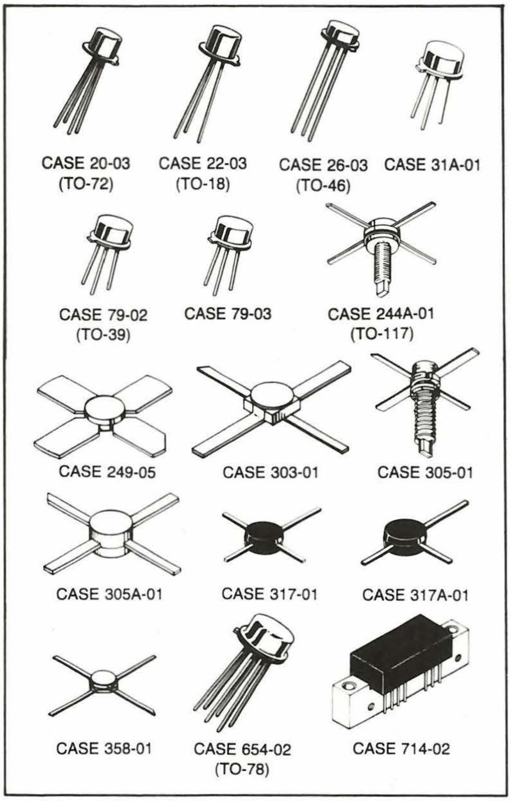
Amplifier power gain and IMD products are a function of the load impedance. For the amplifier design shown above with C4 and C6 adjusted to reflect a load to the drain resulting in a nominal power gain of 9 dB, the 3rd order intercept point (IP) value is 29 dBm. Adjusting C4, C6 to provide larger load values will result in higher gain, smaller bandwidth and lower IP values. For example, a nominal gain of 13 dB can be achieved with an intercept point of 19 dBm.

6

FIGURE 13 – TWO TONE 3RD ORDER INTERCEPT POINT



Example of intercept point plot use:
Assume two in-band signals of –20 dBm at the amplifier input. They will result in a 3rd order IMD signal at the output of –90 dBm. Also, each signal level at the output will be –11 dBm, showing an amplifier gain of 9.0 dB and an intermodulation ratio (IMR) capability of 79 dB. The gain and IMR values apply only for signal levels below compression.



CASE 20-03 (TO-72) CASE 22-03 (TO-18) CASE 26-03 (TO-46) CASE 31A-01

CASE 79-02 (TO-39) CASE 79-03 CASE 244A-01 (TO-117)

CASE 249-05 CASE 303-01 CASE 305-01

CASE 305A-01 CASE 317-01 CASE 317A-01

CASE 358-01 CASE 654-02 (TO-78) CASE 714-02

Small-signal high-frequency transistors and hybrid modules from Motorola are characterized as low-noise amplifiers, oscillators, high-speed switches, Class A linear amplifiers, and Class C amplifiers. Packaging options include plastic/ceramic stripline and metal can.

RF Transistors

7

2N2857
2N3839

2N2857
JAN, JTX, JTXV AVAILABLE
CASE 20-03, STYLE 10
TO-72 (TO-206AF)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

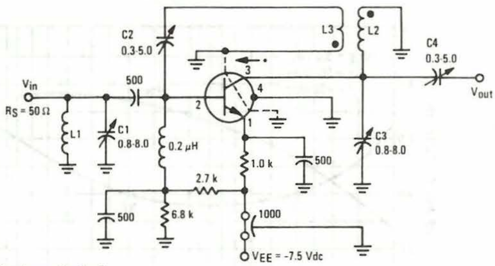
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	2.5	Vdc
Collector Current — Continuous	I_C	40	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	200 1.14	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	300 1.72	mW mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage* ($I_C = 3.0$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 1.0$ μAdc, $I_E = 0$)		$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)		$V_{(BR)EBO}$	2.5	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$) ($V_{CB} = 15$ Vdc, $I_E = 0$, $T_A = 150°C$)	 Both Types 2N3839	I_{CBO}	 — —	 — —	 0.01 1.0	μAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = 3.0$ mAdc, $V_{CE} = 1.0$ Vdc)		h_{FE}	30	—	150	—
SMALL SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(1) ($I_C = 5.0$ mAdc, $V_{CE} = 6.0$ Vdc, f = 100 MHz)	 2N2857 2N3839	f_T	 1000 1000	 — —	 1900 2000	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 0.1 to 1.0 MHz)		C_{cb}	—	0.7	1.0	pF
Small Signal Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 6.0$ Vdc, f = 1.0 kHz)		h_{fe}	50	—	220	—
Collector Base Time Constant ($I_E = 2.0$ mAdc, $V_{CB} = 6.0$ Vdc, f = 31.9 MHz)	 2N2857 2N3839	$rb'C_c$	 4.0 1.0	 — —	 15 15	ps
Noise Figure (Figure 1) ($I_E = 0.1$ mAdc, $V_{CE} = 1.0$ Vdc, $R_S = 50$ ohms, f = 450 MHz)(2) ($I_C = 1.5$ mAdc, $V_{CE} = 6.0$ Vdc, $R_S = 50$ ohms, f = 450 MHz)	 Both Types 2N2857 2N3839	NF	 — — —	 5.8 4.1 —	 — 4.5 3.9	dB
FUNCTIONAL TEST						
Common-Emitter Amplifier Power Gain (Figure 1) ($I_E = 0.1$ mAdc, $V_{CE} = 1.0$ Vdc, f = 450 MHz, $R_S = 50\Omega$))(2) ($I_C = 1.5$ mAdc, $V_{CE} = 6.0$ Vdc, f = 450 MHz, $R_S = 50\Omega$)		G_{pe}	 — 12.5	 11 —	 — 19	dB
Power Output (Figure 2) ($I_E = 12$ mAdc, $V_{CB} = 10$ Vdc, f = 500 MHz)		P_{out}	30	—	—	mW

(1) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.
(2) Micro-Power Specifications.
*Indicates Data in addition to JEDEC Requirements.

FIGURE 1 – TEST CIRCUIT FOR NOISE FIGURE AND POWER GAIN



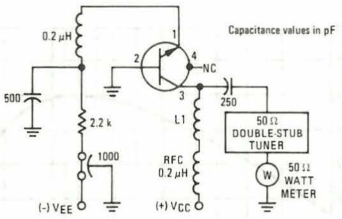
Capacitance values in pF

L1, L2 – Silver-plated brass rod, 1-1/2" long and 1/4" dia. Install at least 1/2" from nearest vertical chassis surface.
L3 – 1/2 turn #16 AWG wire, located 1/4" from and parallel to L2.
* – External interlead shield to isolate collector lead from emitter and base leads.

Neutralization Procedure:

(A) Connect 450-MHz signal generator (with R_S = 50 ohms) to input terminals of amplifier.
(B) Connect 50-ohm RF voltmeter across output terminals of amplifier.
(C) Apply V_{EE}, and with signal generator adjusted for 5 mV output from amplifier, tune C1, C3, and C4 for maximum output.
(D) Interchange connections to signal generator and RF voltmeter.
(E) With sufficient signal applied to output terminals of amplifier, adjust C2 for minimum indication at input.
(F) Repeat steps (A), (B), and (C) to determine if retuning is necessary.

FIGURE 2 – TEST CIRCUIT FOR OSCILLATOR POWER OUTPUT



L1 – 3 turns #16 AWG wire, 3/8" O.D. 1-1/4" long.

FIGURE 3 – NOISE FIGURE versus FREQUENCY

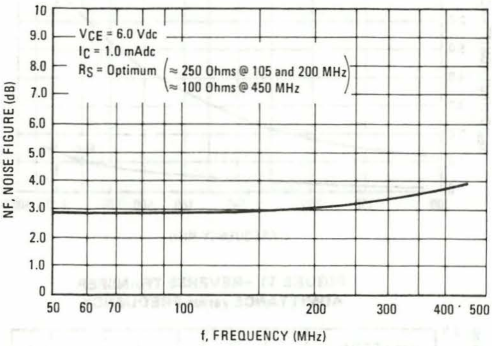


FIGURE 4 – NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT

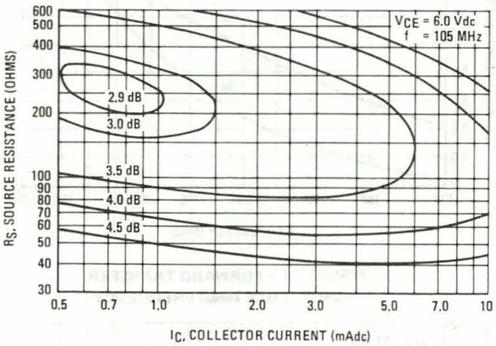


FIGURE 5 – NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT

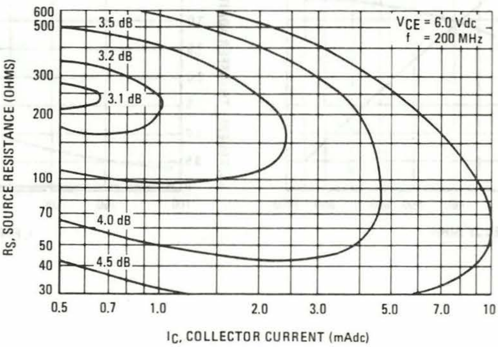


FIGURE 6 – CURRENT-GAIN–BANDWIDTH PRODUCT

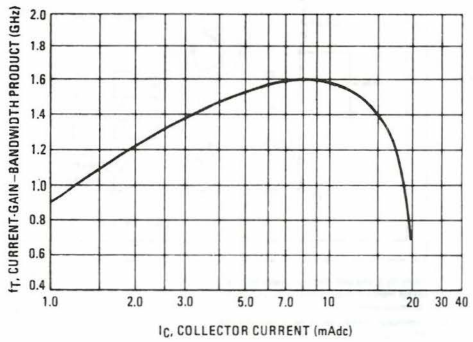


FIGURE 7 – NOISE FIGURE AND POWER GAIN versus COLLECTOR CURRENT

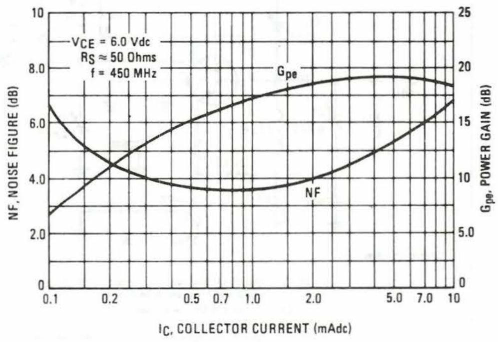


FIGURE 8 – INPUT ADMITTANCE versus FREQUENCY

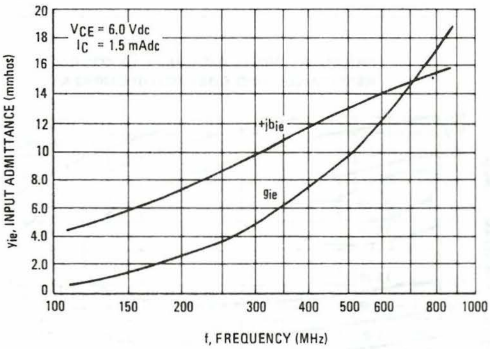


FIGURE 9 – OUTPUT ADMITTANCE versus FREQUENCY

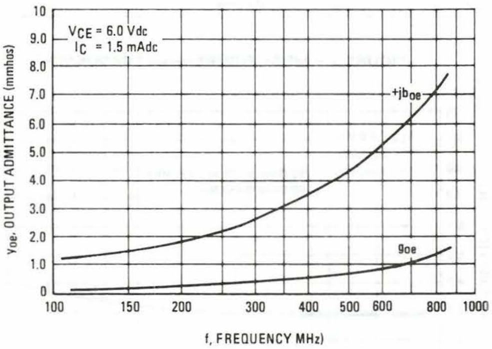


FIGURE 10 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

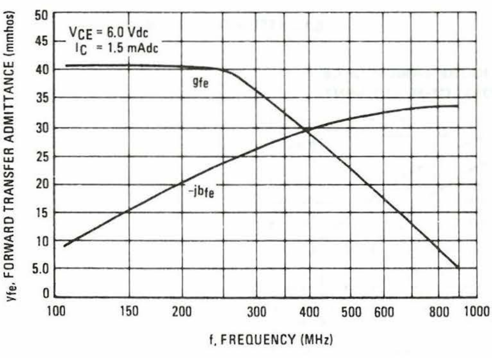
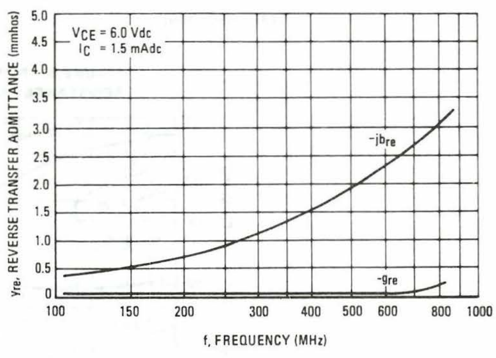


FIGURE 11 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY



7

FIGURE 12 — S_{11}, INPUT REFLECTION COEFFICIENT

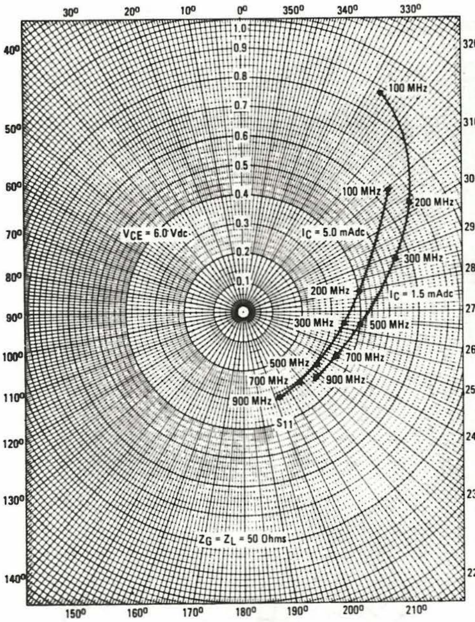


FIGURE 13 — S_{22}, OUTPUT REFLECTION COEFFICIENT

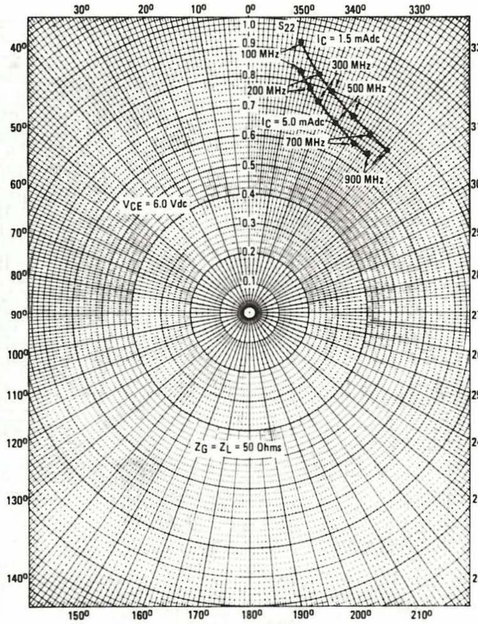


FIGURE 14 — S_{12}, REVERSE TRANSMISSION COEFFICIENT

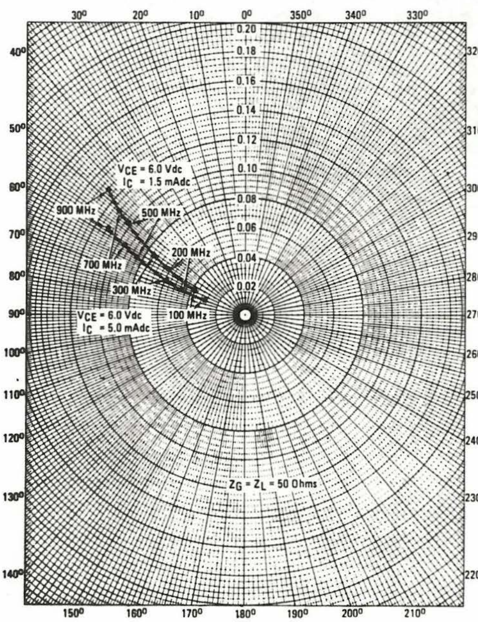
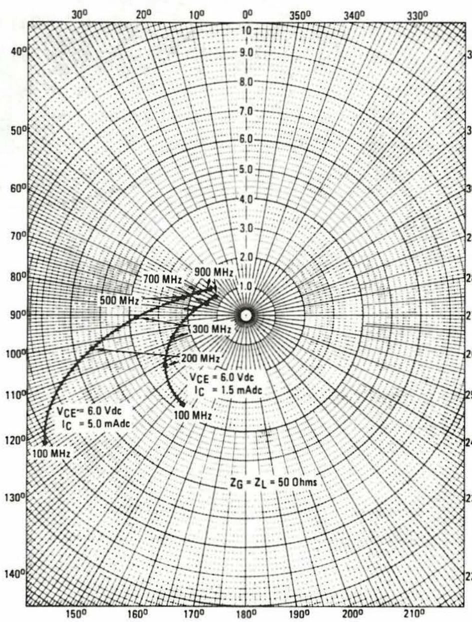
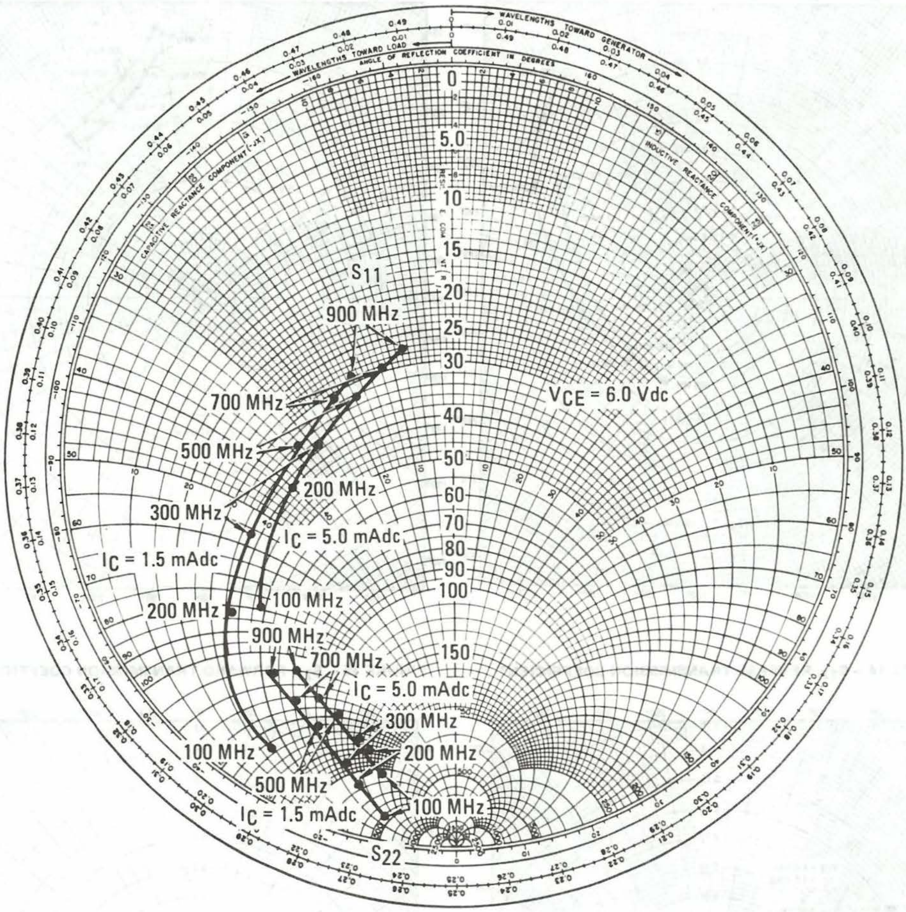


FIGURE 15 — S_{21}, FORWARD TRANSMISSION COEFFICIENT



7

FIGURE 16 – S_{11}, INPUT REFLECTION COEFFICIENT AND S_{22}, OUTPUT REFLECTION COEFFICIENT



7

2N3553

JAN, JTX, JTXV AVAILABLE
CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	65	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	7.0 40	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) (I_C = 200 mAdc, I_B = 0)	$V_{CEO(sus)}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	—	—	0.1	mAdc
Collector Cutoff Current (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 200°C) (V_{CE} = 65 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	I_{CEX}	 — —	 — —	 5.0 1.0	mAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	—	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10	—	—	—
Collector-Emitter Saturation Voltage (I_C = 250 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	—	—	1.0	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 28 Vdc, f = 100 MHz)	f_T	—	500	—	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	8.0	10	pF
FUNCTIONAL TEST (FIGURE 2)					
Amplifier Power Gain (V_{CE} = 28 Vdc, P_{out} = 2.5 Watts, f = 175 MHz)	G_{pe}	10	—	—	dB
Collector Efficiency (V_{CE} = 28 Vdc, P_{out} = 2.5 Watts, f = 175 MHz)	η	50	—	—	%
Power Input (V_{CE} = 28 Vdc, P_{out} = 2.5 Watts, f = 175 MHz)	P_{in}	—	—	0.25	Watt

(1) Pulsed thru a 25 mH inductor.

FIGURE 1 — OUTPUT POWER versus FREQUENCY

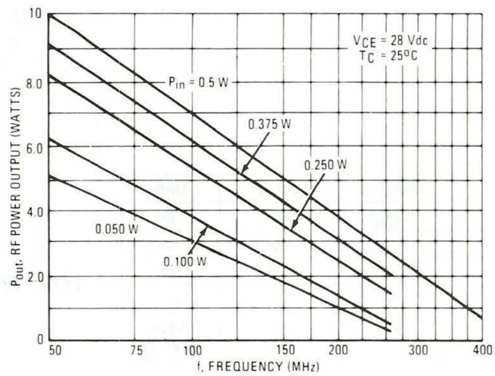
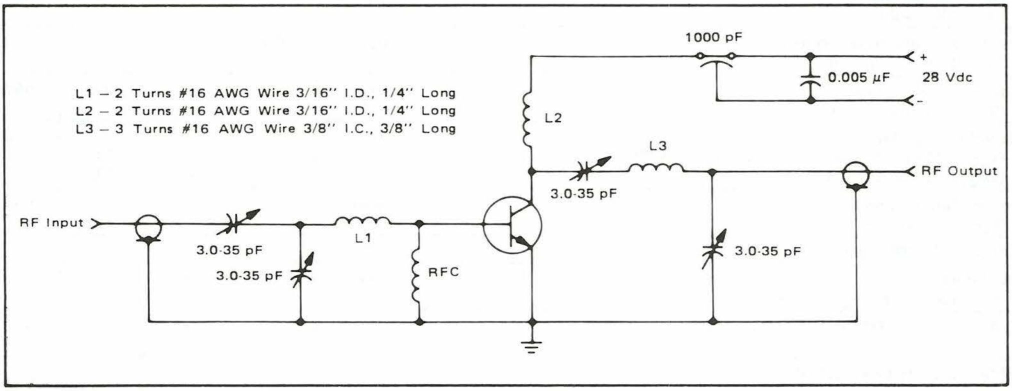


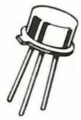
FIGURE 2 — 175 MHz TEST CIRCUIT SCHEMATIC



2N3839 For Specifications, See 2N2857 Data.

2N3866
2N3866A

JAN, JTX, JTXV AVAILABLE
CASE 79-02, STYLE 1
TO-39 (TO-205AD)



HIGH FREQUENCY TRANSISTOR

NPN SILICON

7

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	55	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	0.4	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, R_{BE} = 10 Ω)		$V_{CER(sus)}$	55	—	Vdc
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, I_B = 0)		$V_{CEO(sus)}$	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	3.5	—	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, I_B = 0)		I_{CEO}	—	0.02	mAdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = −1.5 Vdc (Rev.), T_C = 200°C) (V_{CE} = 55 Vdc, V_{BE} = −1.5 Vdc (Rev.)		I_{CEX}	 — —	 5.0 0.1	mAdc
Emitter Cutoff Current (V_{BE} = 3.5 Vdc, I_C = 0)		I_{EBO}	—	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 360 mAdc, V_{CE} = 5.0 Vdc) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	 Both 2N3866 2N3866A	h_{FE}	 5.0 10 25	 — 200 200	—
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 20 mAdc)		$V_{CE(sat)}$	—	1.0	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	 2N3866 2N3866A	f_T	 500 800	 — —	MHz
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	3.0	pF
FUNCTIONAL TEST (FIGURE 1)					
Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 1.0 W, f = 400 MHz)		G_{pe}	10	—	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 1.0 W, f = 400 MHz)		η	45	—	%

FIGURE 1 — 400 MHz TEST CIRCUIT SCHEMATIC

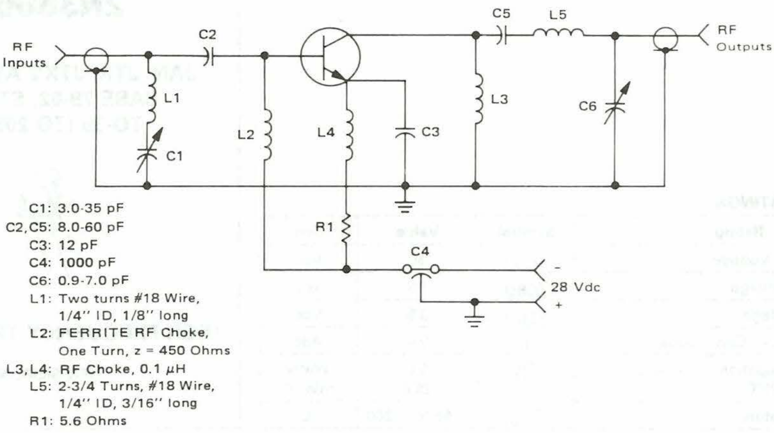


FIGURE 2 — POWER OUTPUT versus FREQUENCY (Class C)

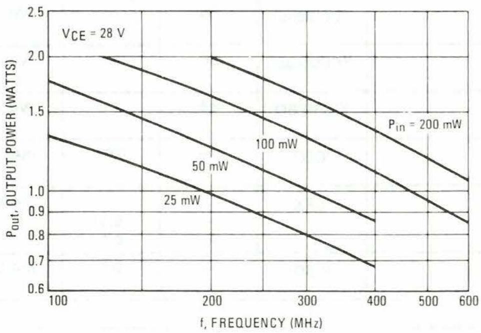


FIGURE 3 — CURRENT-GAIN — BANDWIDTH PRODUCT

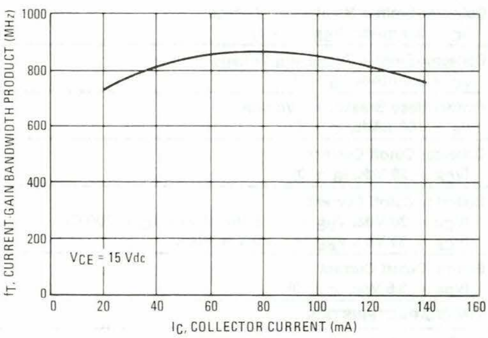


FIGURE 4 — COLLECTOR-BASE TIME CONSTANT

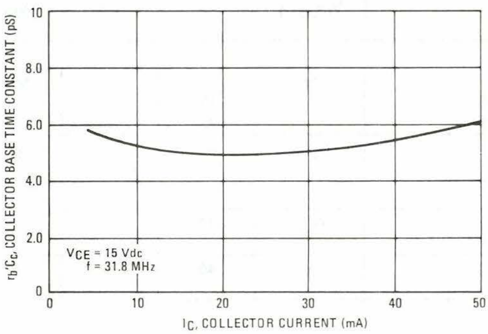


FIGURE 5 — OUTPUT CAPACITANCE

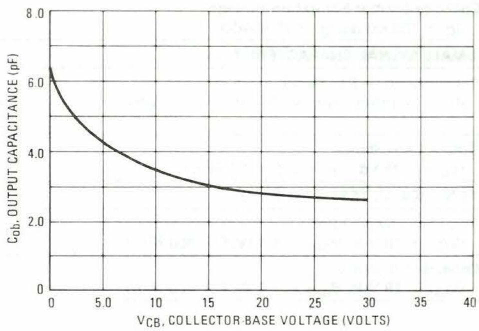


FIGURE 6 – OUTPUT POWER versus INPUT POWER (CLASS C)

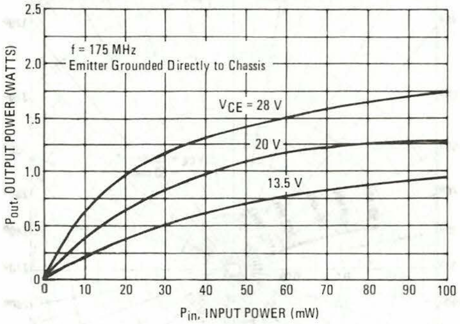


FIGURE 7 – SMALL-SIGNAL CURRENT GAIN

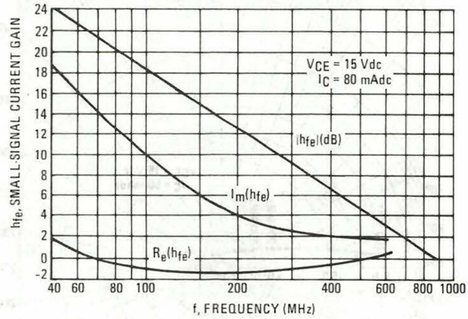


FIGURE 8 – LARGE-SIGNAL SERIES EQUIVALENT IMPEDANCES

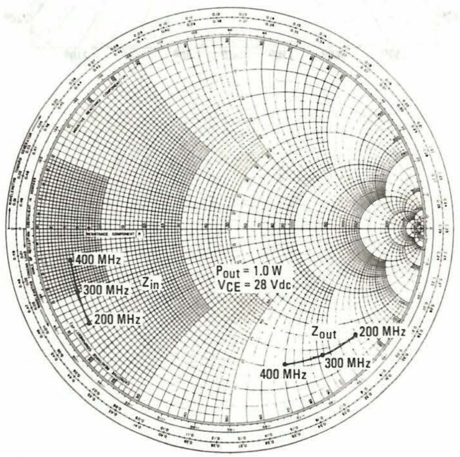
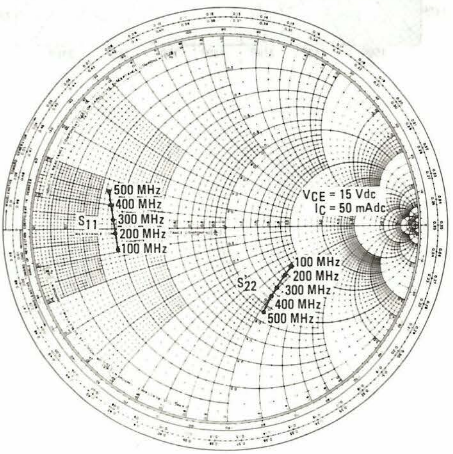


FIGURE 9 – S_{11} AND S_{22} versus FREQUENCY



7

FIGURE 10 — S_{21} versus FREQUENCY

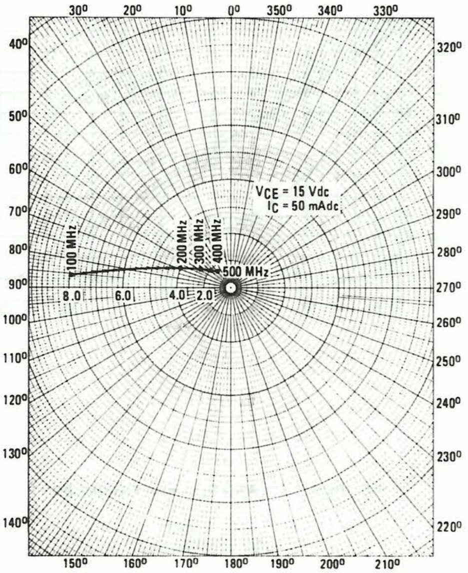
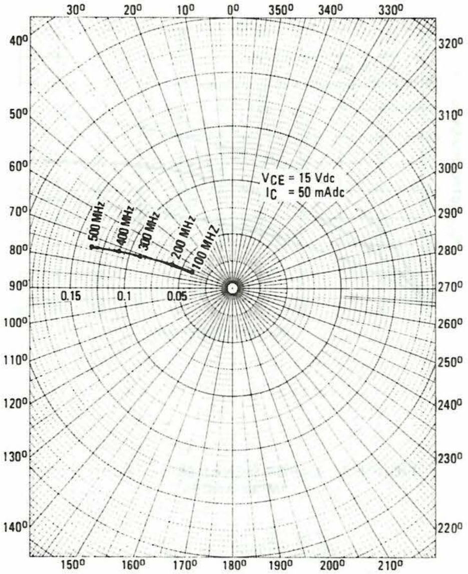


FIGURE 11 — S_{12} versus FREQUENCY



7

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	400	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W

2N3948

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

7

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	20	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	36	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.5	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 — —	 0.1 100	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	15	—	—
SMALL SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_E = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	700	—	MHz
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	4.5	pF
FUNCTIONAL TEST (FIGURE 1)				
Power Gain (V_{CC} = 13.6 Vdc, f = 400 MHz, P_{in} = 0.25 W)	G_{pe}	6.0	—	dB
Output Power (V_{CC} = 13.6 Vdc, f = 400 MHz, P_{in} = 0.25 W)	P_{out}	1.0	—	Watt
Collector Efficiency (V_{CC} = 13.6 Vdc, f = 400 MHz, P_{in} = 0.25 W)	η	45	—	%

FIGURE 1 – 400 MHz RF AMPLIFIER TEST CIRCUIT

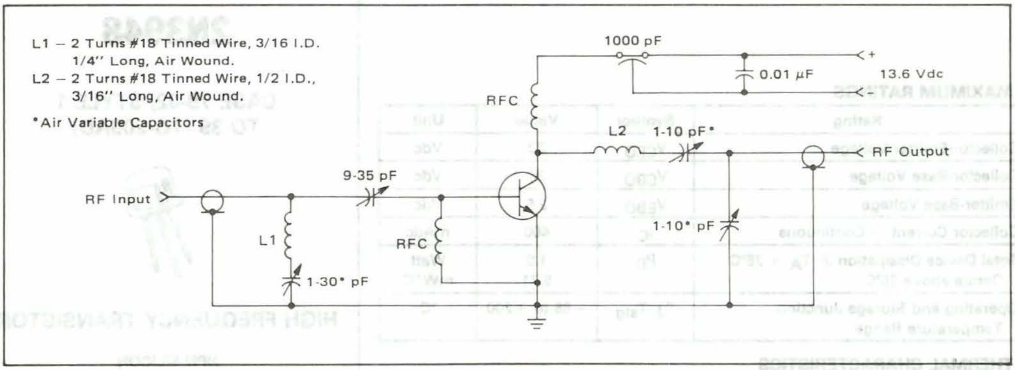


FIGURE 2 – OUTPUT POWER versus FREQUENCY

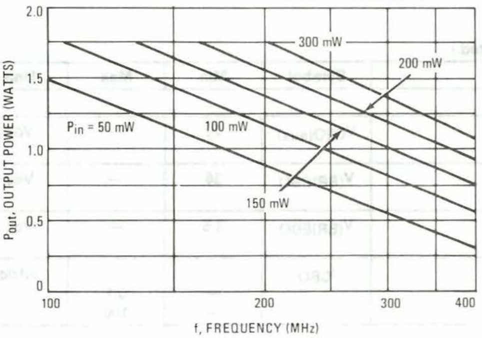
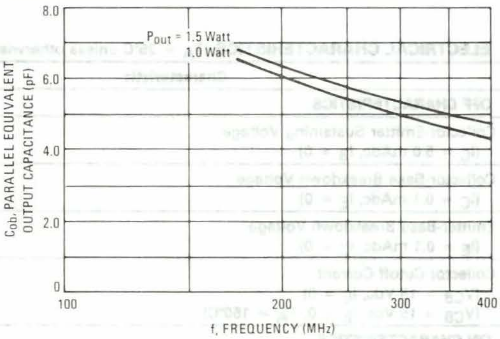


FIGURE 3 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE



7

2N3959
2N3960

JAN, JTX, JTXV AVAILABLE
CASE 22-03, STYLE 1
TO-18 (TO-206AA)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	Vdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	400 2.3	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	750 4.3	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.233	°C/mW
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.436	°C/mW

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	12	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)		$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)		$V_{(BR)EBO}$	4.5	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 10$ Vdc, $V_{EB} = 2.0$ Vdc) ($V_{CE} = 10$ Vdc, $V_{EB} = 2.0$ Vdc, $T_A = 150°C$)		I_{CEX}	 — —	 — —	 0.005 5.0	μAdc
Collector Forward Current ($V_{CE} = 5.0$ Vdc, $V_{BE} = 0.4$ Vdc)		I_{CEX}	—	—	1.0	μAdc
Base Cutoff Current ($V_{CE} = 10$ Vdc, $V_{EB} = 2.0$ Vdc)		I_{BL}	—	—	0.005	μAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 1.0$ Vdc)		h_{FE}	 25 40 25	 — — —	 — 400 —	—
Collector-Emitter Saturation Voltage ($I_C = 1.0$ mAdc, $I_B = 0.1$ mAdc) ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc)		$V_{CE(sat)}$	 — —	 — —	 0.2 0.3	Vdc
Base-Emitter On Voltage ($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 30$ mAdc, $V_{CE} = 1.0$ Vdc)		$V_{BE(on)}$	 — —	 — —	 0.8 1.0	Vdc
SMALL SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product ($I_C = 5.0$ mAdc, $V_{CE} = 4.0$ Vdc, f = 100 MHz)	 2N3959 2N3960	f_T	 1000 1300	 — —	 — —	MHz
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	2N3959 2N3960		1300 1600	— —	— —	
($I_C = 30$ mAdc, $V_{CE} = 4.0$ Vdc, f = 100 MHz)	2N3959 2N3960		1000 1200	— —	— —	
Output Capacitance ($V_{CB} = 4.0$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	2.0	2.5	pF

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 MHz)		C_{ibo}	—	1.5	2.5	pF
Collector Base Time Constant		rb'C_c				ps
(I_C = 5.0 mAdc, V_{CE} = 4.0 Vdc)	2N3959		—	—	30	
	2N3960		—	—	50	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N3959		—	—	25	
	2N3960		—	—	40	
(I_C = 30 mAdc, V_{CE} = 4.0 Vdc)	2N3959		—	—	30	
	2N3960		—	—	50	
SWITCHING CHARACTERISTICS (FIGURE 7)						
Turn-On Delay Time		$t_{d(on)}$				ns
(I_C = 10 mAdc, V_{out} = 1.0 Vdc)			—	2.4	—	
(I_C = 30 mAdc, V_{out} = 1.0 Vdc)			—	2.0	—	
Rise Time		t_r				ns
(I_C = 10 mAdc, V_{out} = 1.0 Vdc)	Both Devices		—	3.0	—	
(I_C = 30 mAdc, V_{out} = 1.0 Vdc)	2N3959		—	2.2	—	
	2N3960		—	1.7	—	
Turn-Off Delay Time		$t_{d(off)}$				ns
(I_C = 10 mAdc, V_{out} = 1.0 Vdc)			—	1.6	—	
(I_C = 30 mAdc, V_{out} = 1.0 Vdc)			—	1.6	—	
Fall Time		t_f				ns
(I_C = 10 mAdc, V_{out} = 1.0 Vdc)	Both Devices		—	3.3	—	
(I_C = 30 mAdc, V_{out} = 1.0 Vdc)	2N3959		—	2.3	—	
	2N3960		—	1.9	—	

7

FIGURE 1 – TYPICAL DC CURRENT GAIN

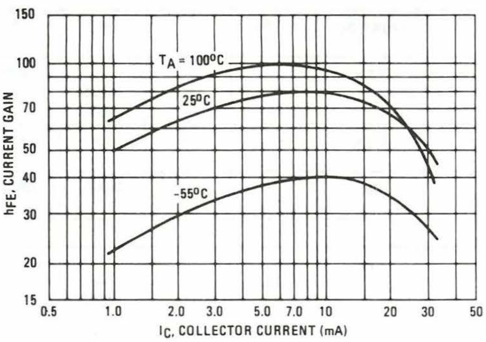


FIGURE 2 – TYPICAL CURRENT-GAIN – BANDWIDTH PRODUCT

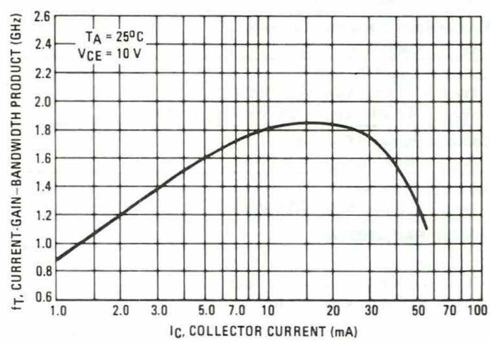


FIGURE 3 – TYPICAL COLLECTOR-BASE TIME CONSTANT

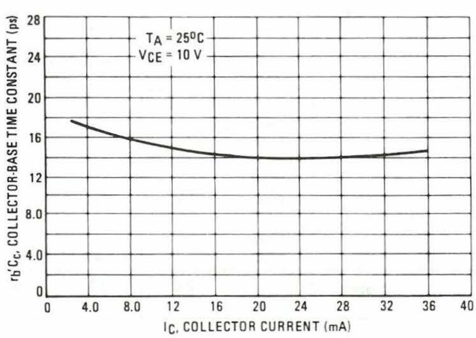
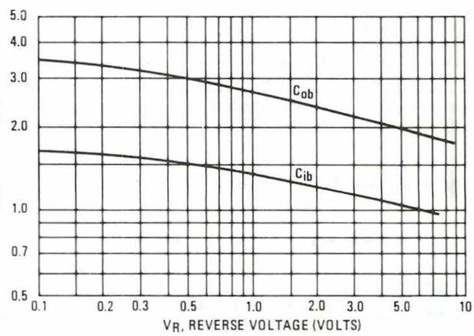


FIGURE 4 – TYPICAL JUNCTION CAPACITANCE



TURN-ON AND TURN-OFF TIMES

FIGURE 5 – V_{out} = 1.0 Vdc

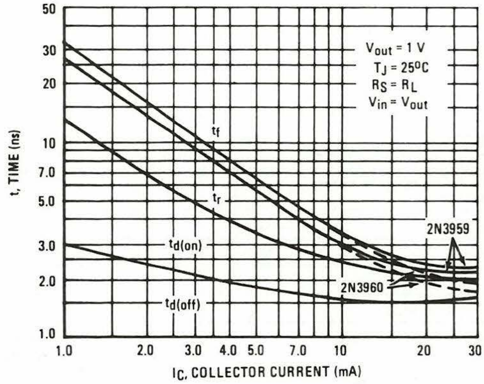


FIGURE 6 – V_{out} = 2.0 Vdc

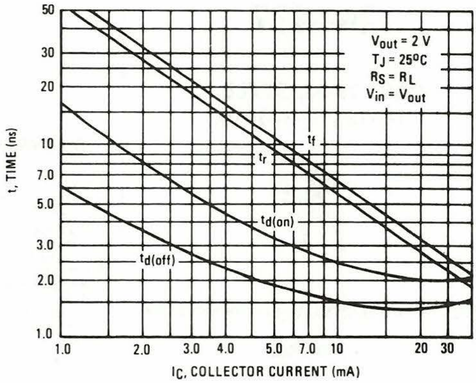
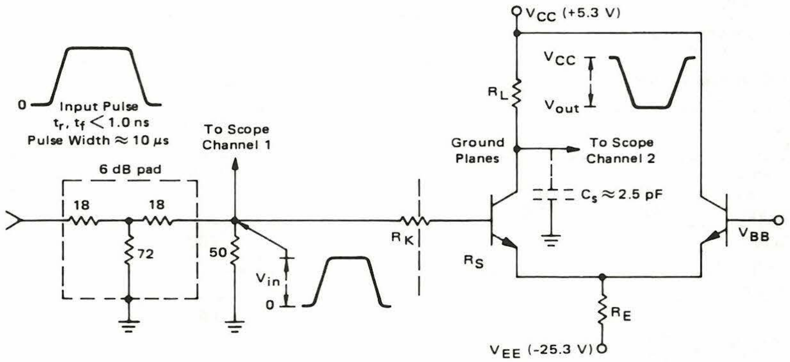


FIGURE 7 – SWITCHING TIMES TEST CIRCUIT



This test set up is designed to simulate a cascade of identical stages. ∴The source resistance (R_S) equals the load resistance (R_L). Values used in the test are shown in the table.

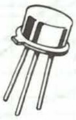
For V_{in} = V_{out} = 1 V, V_{BB} = +0.5 V, R_L & R_K values appropriately reduced.

V_{in} = V_{out} = 2 volts, V_{BB} = +1.0V			
I_C (mA)	R_E (kΩ)	R_L (Ω)	R_K (Ω)
1.0	24.0	2.0 k	2.0 k
3.0	8.2	680	680
10	2.4	200	180
30	0.8	68	36

7

2N4427

CASE 79-02, STYLE 1
TO-39 (TO-205AD)



HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	2.0	Vdc
Base Current	I_B	400	mAdc
Collector Current — Continuous	I_C	400	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.5 20	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, R_{BE} = 10 ohms)	$V_{CER(sus)}$	40	—	Vdc
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	20	—	Vdc
Collector Cutoff Current (V_{CE} = 12 Vdc, I_B = 0)	I_{CEO}	—	0.02	mAdc
Collector Cutoff Current (V_{CE} = 40 Vdc, V_{BE} = −1.5 Vdc) (V_{CE} = 12 Vdc, V_{BE} = −1.5 Vdc, T_C = +150°C)	I_{CEV}	 — —	 0.1 5.0	mAdc
Emitter Cutoff Current (V_{EB} = 2.0 Vdc, I_C = 0)	I_{EBO}	—	0.1	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 100 mAdc, V_{CE} = 5.0 Vdc) (I_C = 360 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	 10 5.0	 200 —	—
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 20 mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
SMALL SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	500	—	MHz
Output Capacitance (V_{CB} = 12 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	4.0	pF
FUNCTIONAL TEST (FIGURE 2)				
Common-Emitter Amplifier Power Gain (P_{in} = 100 mW, V_{CC} = 12 Vdc, f = 175 MHz)	G_{pe}	10	—	dB
Collector Efficiency (P_{out} = 1.0 W, V_{CC} = 12 Vdc, f = 175 MHz)	η	50	—	%
Power Input (P_{out} = 1.0 W, V_{CC} = 12 Vdc, f = 175 MHz)	P_{in}	—	100	mW

FIGURE 1 – POWER OUTPUT versus FREQUENCY

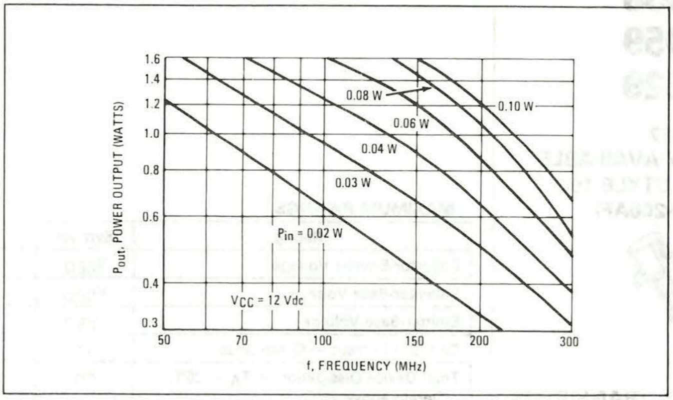
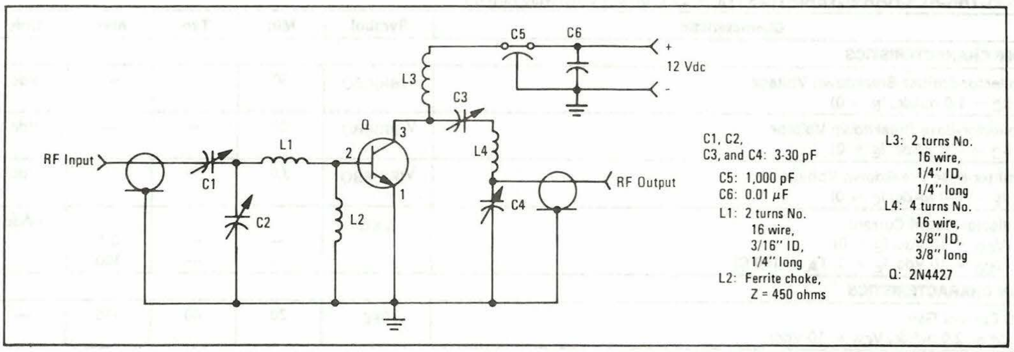


FIGURE 2 – 175 MHz RF AMPLIFIER CIRCUIT FOR POWER-OUTPUT TEST



7

2N4957
2N4958
2N4959
2N5829

2N4957
JAN, JTX, JTXV AVAILABLE
CASE 20-03, STYLE 10
TO-72 (TO-206AF)

HIGH FREQUENCY TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0) (V_{CB} = 10 Vdc, I_E = 0, T_A = 150°C)		I_{CBO}	 — —	 — —	 0.1 100	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)		h_{FE}	20	40	150	—
SMALL SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(1) (I_E = 2.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	 2N4957, 2N5829 2N4958, 2N4959	f_T	 1200 1000	 1600 1500	 2500 2500	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	—	0.4	0.8	pF
Small Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	20	—	200	—
Collector Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 10 Vdc, f = 63.6 MHz)		$r_b'C_c$	1.0	—	8.0	ps
Noise Figure (Figure 1) (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 450 MHz)	 2N5829 2N4957 2N4958 2N4959	NF	 — — — —	 2.3 2.6 2.9 3.2	 2.5 3.0 3.3 3.8	dB
FUNCTIONAL TEST						
Common-Emitter Amplifier Power Gain (Figure 1) (V_{CE} = 10 Vdc, I_C = 2.0 mAdc, f = 450 MHz)	 2N4957, 2N5829 2N4958 2N4959	G_{pe}	 17 16 15	 — — —	 25 25 25	dB

(1) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 — NOISE FIGURE AND POWER GAIN TEST CIRCUIT

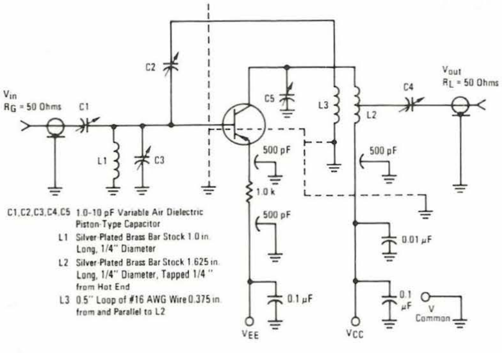


FIGURE 2 — UNILATERALIZED POWER GAIN versus FREQUENCY

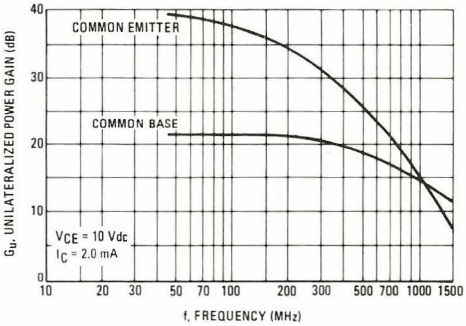


FIGURE 3 — NOISE FIGURE versus FREQUENCY

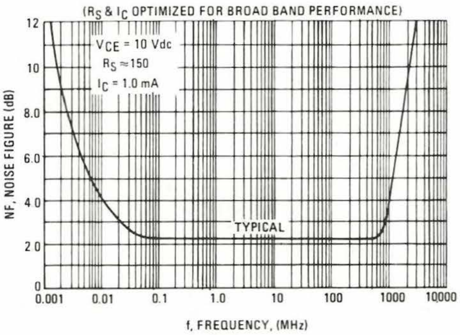


FIGURE 4 — NOISE FIGURE AND POWER GAIN versus COLLECTOR CURRENT

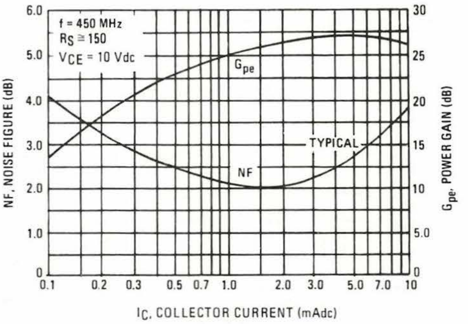


FIGURE 5 — CONTOURS OF NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT

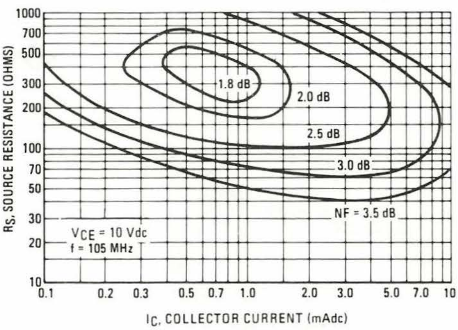
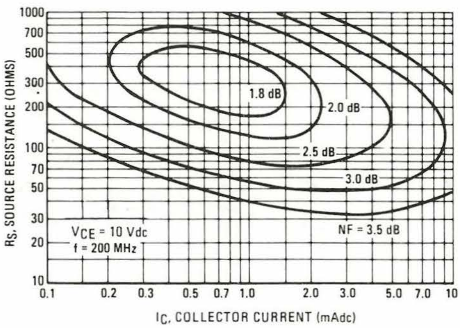


FIGURE 6 — CONTOURS OF NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT



COMMON EMITTER CIRCUIT DESIGN DATA

(V_{CE} = 10 Vdc, I_C = 2.0 mAdc)

FIGURE 7 – TRANSDUCER GAIN versus FREQUENCY

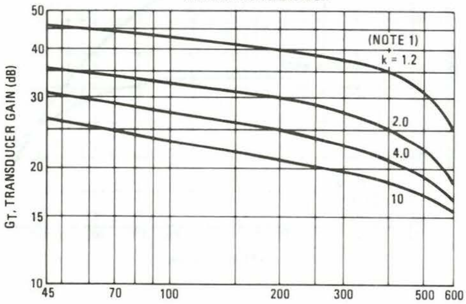


FIGURE 8 – LINVILL STABILITY FACTOR versus FREQUENCY

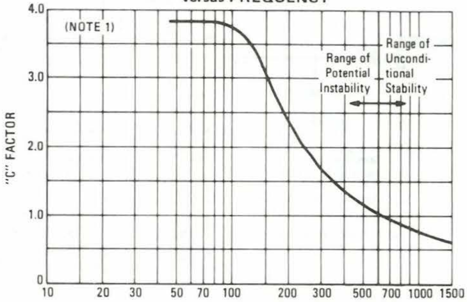


FIGURE 9 – LOAD ADMITTANCE versus FREQUENCY (REAL)

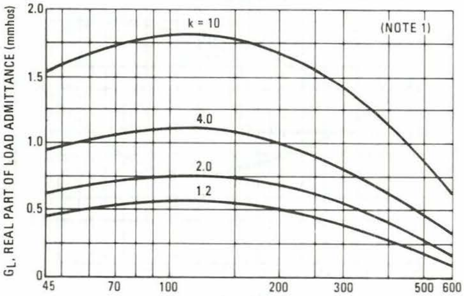


FIGURE 10 – LOAD ADMITTANCE versus FREQUENCY (IMAGINARY)

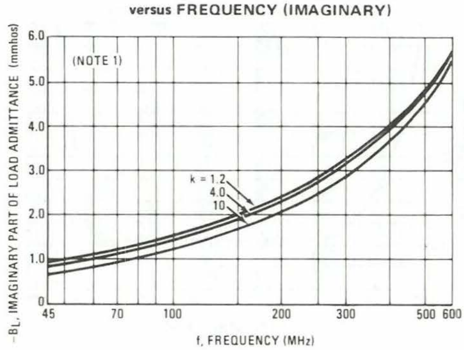


FIGURE 11 – SOURCE ADMITTANCE versus FREQUENCY (REAL)

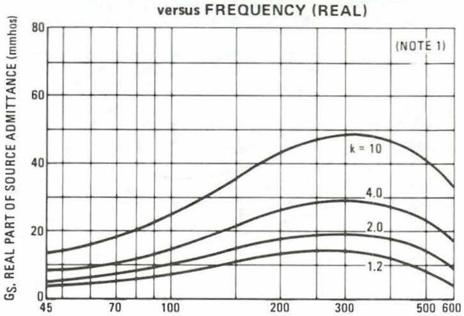
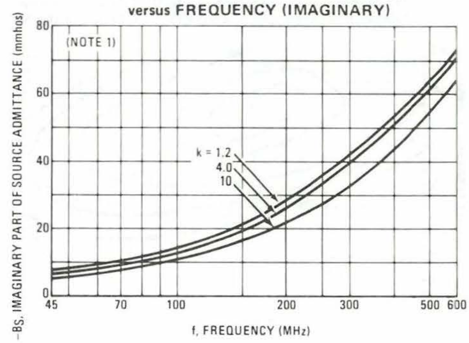


FIGURE 12 – SOURCE ADMITTANCE versus FREQUENCY (IMAGINARY)



NOTE 1

Figures 7 through 18 are included to assist the circuit designer in determining the stability of his particular circuit. Two stability criteria are given in these figures.

The Linvill "C" factor* is a measure of transistor stability when the input and output are terminated in the worst-case (open circuit) condition. When "C" is less than 1.0, the circuit is unconditionally stable. When "C" is greater than 1.0, the circuit is potentially unstable.

The Stern "K" factor† has been defined to determine the stability of a practical amplifier terminated in finite load and source admittances. If "K" is greater than 1.0, the circuit will be stable. If less than 1.0, the circuit will be unstable. For further details, see Application Note AN-215A.

* "Transistors and Active Circuits," Linvill and Gibbons, McGraw Hill, 1961.

† "Stability and Power Gain of Tuned Transistor Amplifiers," Arthur P. Stern, Proc. I.R.E., March 1967.

COMMON BASE CIRCUIT DESIGN DATA

(V_{CB} = 10 Vdc, I_C = 2.0 mAdc)

FIGURE 13 – TRANSDUCER GAIN versus FREQUENCY

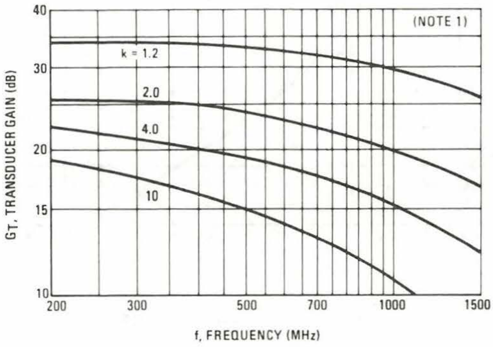


FIGURE 14 – LINVILL STABILITY FACTOR versus FREQUENCY

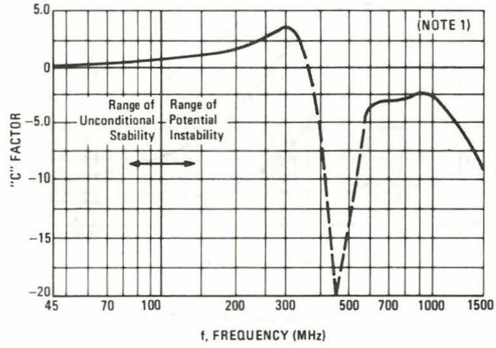


FIGURE 15 – LOAD ADMITTANCE versus FREQUENCY (REAL)

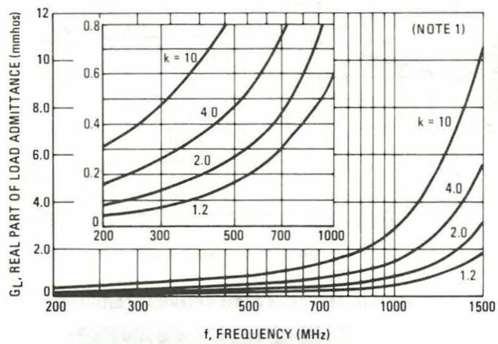


FIGURE 16 – LOAD ADMITTANCE versus FREQUENCY (IMAGINARY)

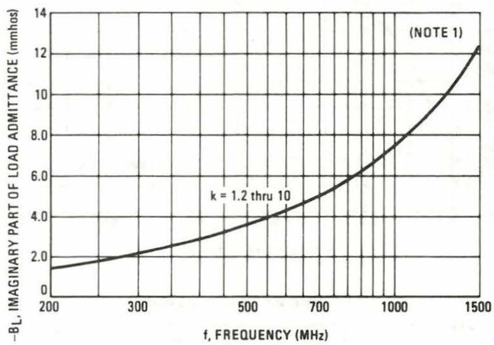


FIGURE 17 – SOURCE ADMITTANCE versus FREQUENCY (REAL)

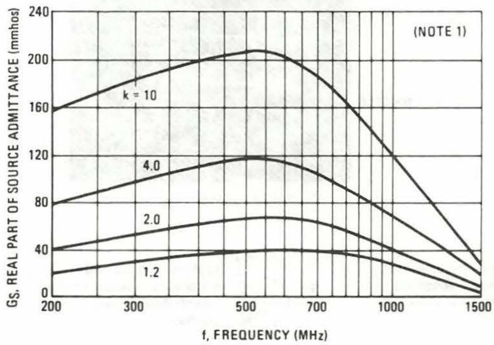


FIGURE 18 – SOURCE ADMITTANCE versus FREQUENCY (IMAGINARY)

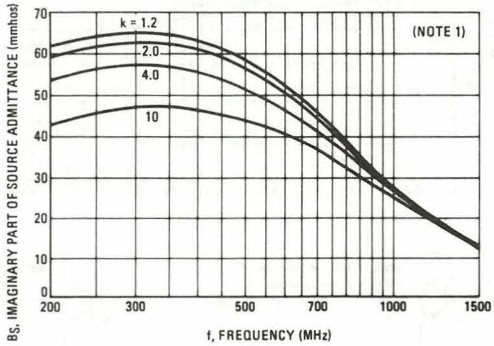


FIGURE 19 – SMALL-SIGNAL CURRENT GAIN versus FREQUENCY

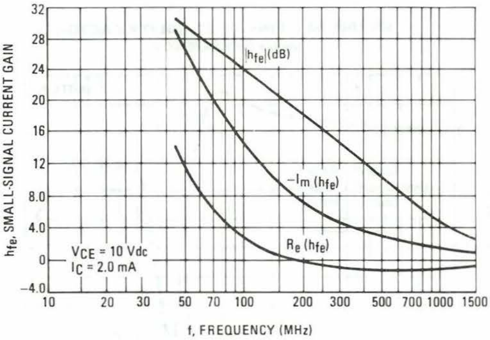


FIGURE 20 – POLAR h_{fe}

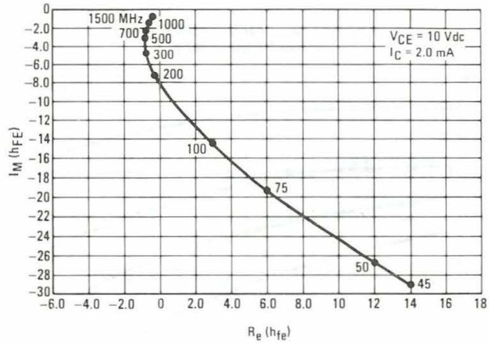


FIGURE 21 – f_T versus COLLECTOR CURRENT

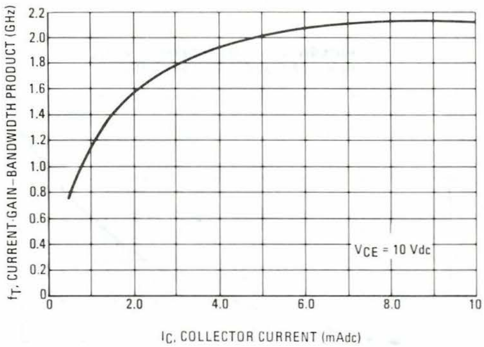


FIGURE 22 – DC CURRENT GAIN

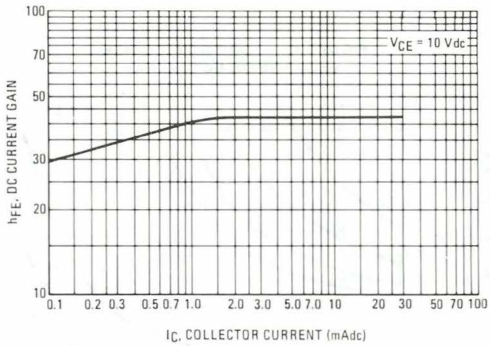


FIGURE 23 – CAPACITANCE

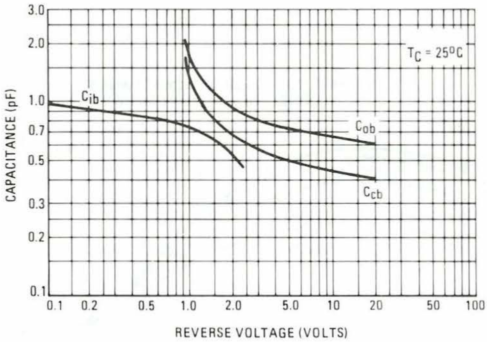
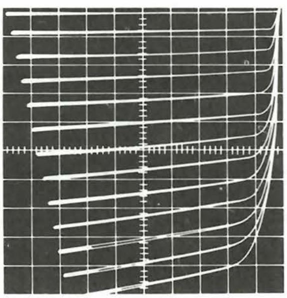


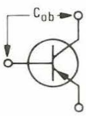
FIGURE 24 – COLLECTOR CHARACTERISTICS

VERTICAL SCALE
I_C = 1.0 mA/DIV

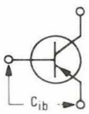


I_b = 0.02 mA/STEP

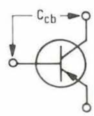
HORIZONTAL SCALE – V_{CE} = 1.0 V/DIV



Apply reverse bias between collector and base and measure capacitance between these terminals. Emitter is open.



Apply reverse bias between emitter and base and measure capacitance between these terminals. Collector is open.



Apply reverse bias between collector and base and measure capacitance between these terminals. Emitter is guarded.

7

Y PARAMETERS versus CURRENT

(f = 450 MHz)

COMMON BASE

V_{CB} = 10 Vdc ——— V_{CB} = 15 Vdc — — —

COMMON EMITTER

V_{CE} = 10 Vdc ——— V_{CE} = 15 Vdc — — —

FIGURE 25 – INPUT ADMITTANCE

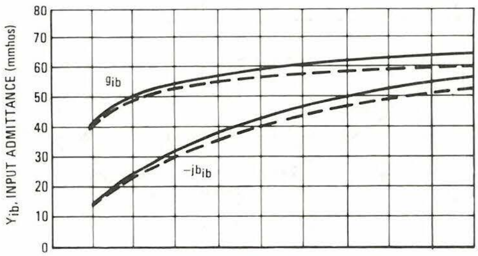


FIGURE 26 – INPUT ADMITTANCE

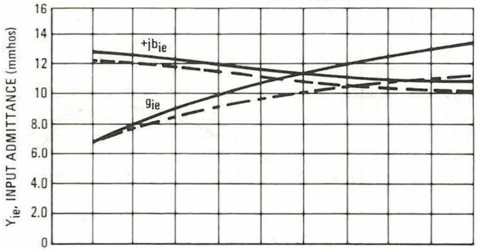


FIGURE 27 – FORWARD TRANSFER ADMITTANCE

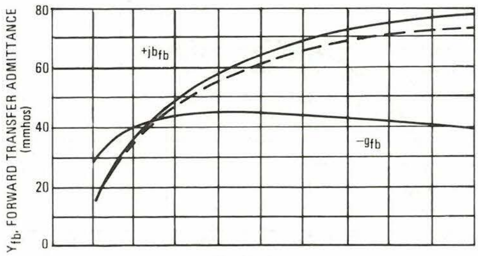


FIGURE 28 – FORWARD TRANSFER ADMITTANCE

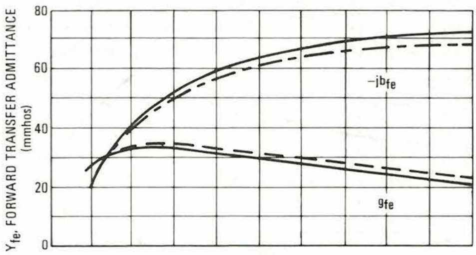


FIGURE 29 – OUTPUT ADMITTANCE

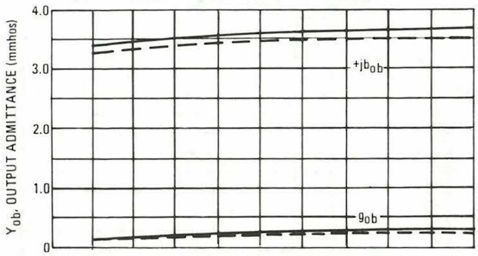


FIGURE 30 – OUTPUT ADMITTANCE

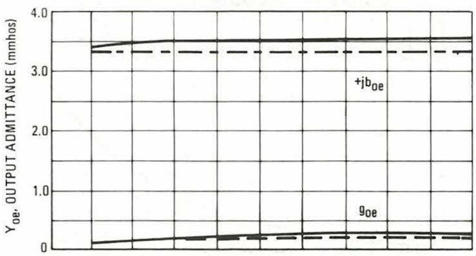


FIGURE 31 – REVERSE TRANSFER ADMITTANCE

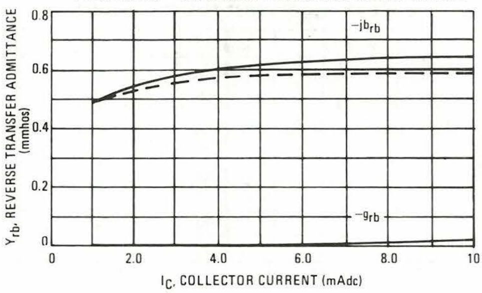
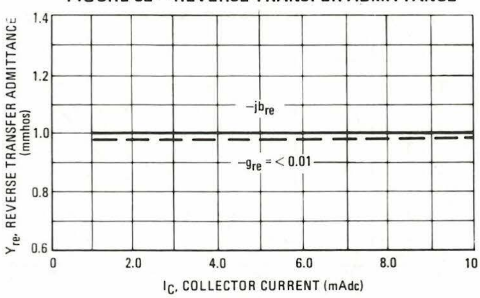


FIGURE 32 – REVERSE TRANSFER ADMITTANCE



7

COMMON BASE y PARAMETER VARIATIONS

(V_{CB} = 10 Vdc, I_C = 2.0 mAdc)

y PARAMETERS versus FREQUENCY

FIGURE 33 – y_{ib} INPUT ADMITTANCE

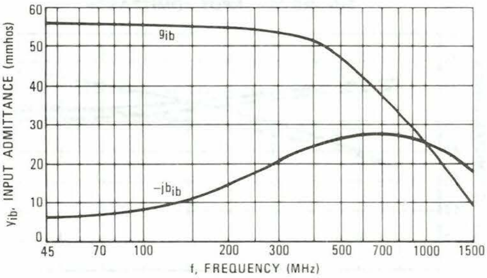


FIGURE 35 – y_{fb} FORWARD TRANSFER ADMITTANCE

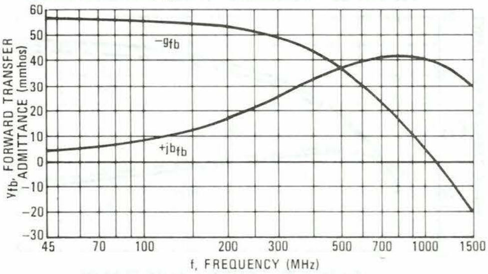


FIGURE 37 – y_{ob} OUTPUT ADMITTANCE

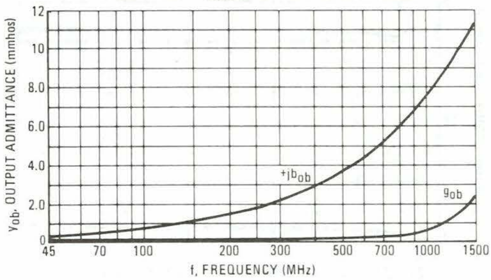
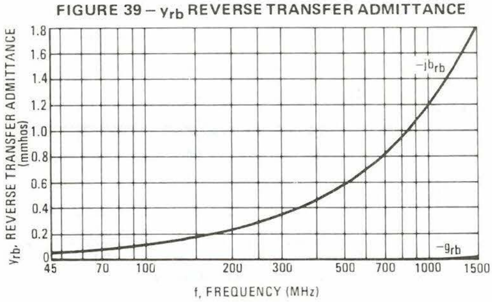


FIGURE 39 – y_{rb} REVERSE TRANSFER ADMITTANCE



POLAR y PARAMETERS versus FREQUENCY

FIGURE 34 – y_{ib} INPUT ADMITTANCE

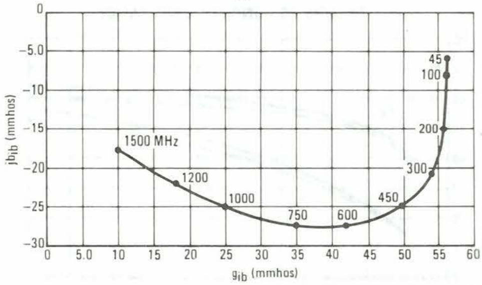


FIGURE 36 – y_{fb} FORWARD TRANSFER ADMITTANCE

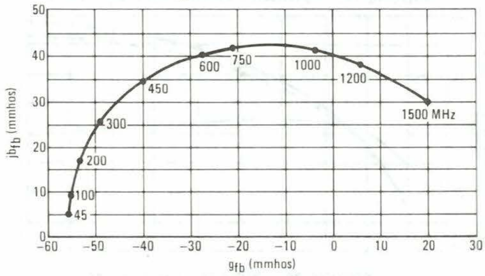


FIGURE 38 – y_{ob} OUTPUT ADMITTANCE

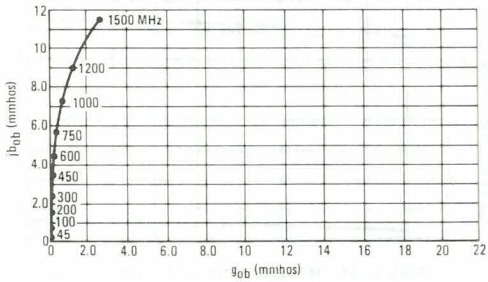
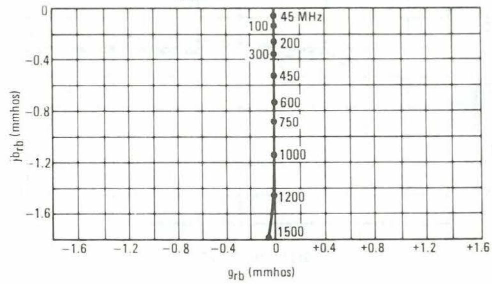


FIGURE 40 – y_{rb} REVERSE TRANSFER ADMITTANCE



COMMON EMITTER y PARAMETER VARIATIONS

(V_{CE} = 10 Vdc, I_C = 2.0 mAdc)

y PARAMETERS versus FREQUENCY

FIGURE 41 – y_{ie} INPUT ADMITTANCE

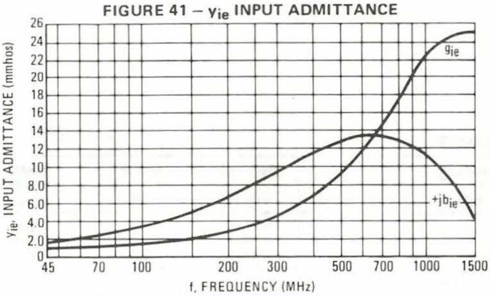


FIGURE 43 – y_{fe} FORWARD TRANSFER ADMITTANCE

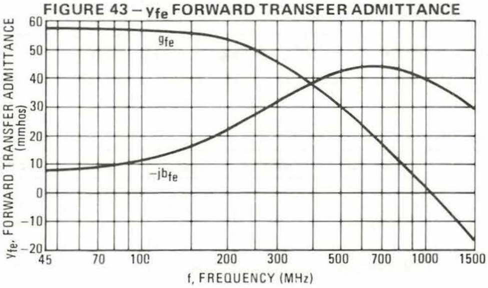


FIGURE 45 – y_{oe} OUTPUT ADMITTANCE

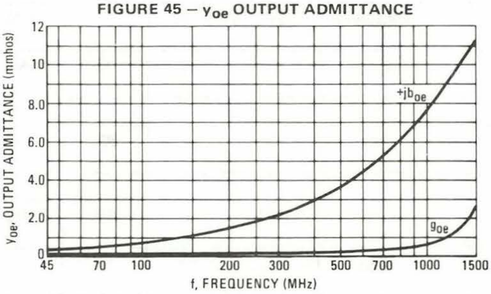
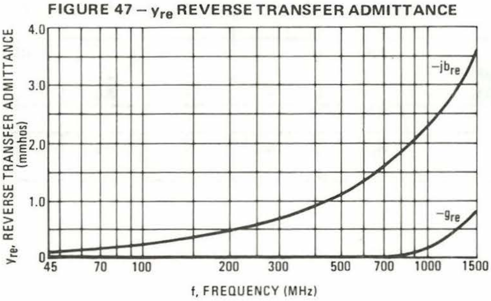


FIGURE 47 – y_{re} REVERSE TRANSFER ADMITTANCE



POLAR y PARAMETERS versus FREQUENCY

FIGURE 42 – y_{ie} INPUT ADMITTANCE

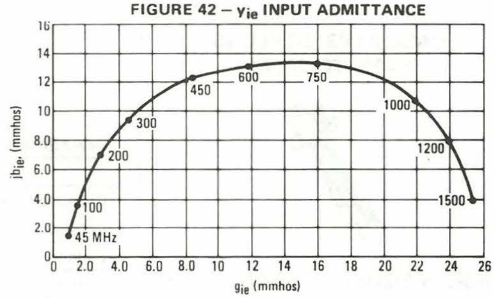


FIGURE 44 – y_{fe} FORWARD TRANSFER ADMITTANCE

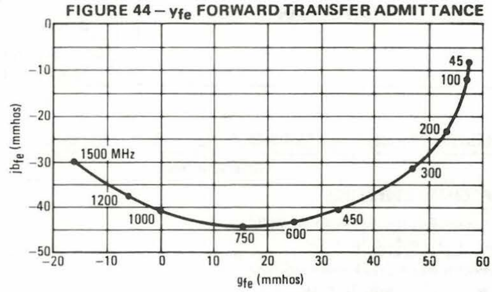


FIGURE 46 – y_{oe} OUTPUT ADMITTANCE

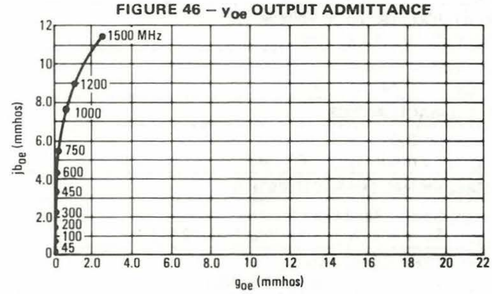
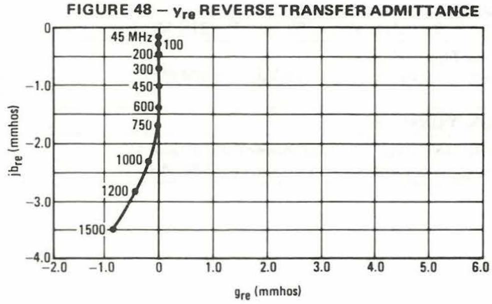


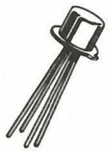
FIGURE 48 – y_{re} REVERSE TRANSFER ADMITTANCE



7

2N5031
2N5032

CASE 20-03, STYLE 10
TO-72 (TO-206AF)



HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

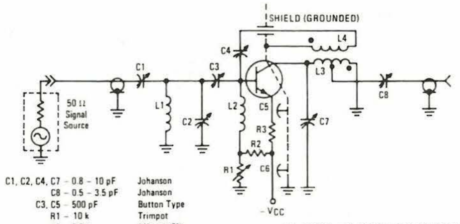
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	10	Vdc
Collector-Base Voltage	V_{CBO}	15	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	20	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	200 1.14	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

7

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	10	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.01$ mAdc, $I_E = 0$)		$V_{(BR)CBO}$	15	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.01$ mAdc, $I_C = 0$)		$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 6.0$ Vdc, $I_E = 0$)		I_{CBO}	—	1.0	10	nAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 6.0$ Vdc)		h_{FE}	25	—	300	—
SMALL SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product ($I_C = 5.0$ mAdc, $V_{CE} = 6.0$ Vdc, f = 100 MHz)		f_T	1000	—	3500	MHz
Collector-Base Capacitance ($V_{CE} = 6.0$ Vdc, $I_E = 0$, f = 0.1 MHz)		C_{cb}	—	1.3	1.5	pF
Collector Base Time Constant ($I_C = 6.0$ mAdc, $V_{CE} = 6.0$ Vdc, f = 31.8 MHz)		$r_b'C_c$	—	5.0	—	ps
Noise Figure (Figure 1) ($I_C = 1.0$ mAdc, $V_{CE} = 6.0$ Vdc, f = 450 MHz)	 2N5031 2N5032	NF	 — —	 — —	 2.5 3.0	dB
FUNCTIONAL TEST						
Common-Emitter Amplifier Power Gain (Figure 1) ($V_{CE} = 6.0$ Vdc, $I_C = 1.0$ mAdc, f = 450 MHz)		G_{pe}	14	17	25	dB

FIGURE 1 – POWER GAIN AND NOISE FIGURE TEST CIRCUIT



C1, C2, C4, C7 – 0.8 – 10 pF Johanson
C8 – 0.5 – 3.5 pF Johanson
C3, C5 – 500 pF Button Type
R1 – 10 k Trimpot
R2 – 2.7 k 1/4 watt 5%
R3 – 1.0 k 1/4 watt 5%
L1 – 1/4" Brass Rod, Solder Plated, 1-1/8" long. Placed 5/8" from the socket and in parallel with the shield, which bisects the socket. The ungrounded side is soldered directly to the ungrounded side of C2.
L2 – 0.22 μH
L3 – 1/4" Brass Rod, Solder Plated, 1-1/2" long. Placed 1/2" from the socket and in parallel with shield, which bisects the socket. The ungrounded side is soldered directly to the ungrounded side of C7. Output tap is 15/16" from ground.
L4 – 1/2 Turn #16, 5/16" above L3 and 5/8" long, (over L3)

FIGURE 2 – COLLECTOR-BASE CAPACITANCE versus VOLTAGE

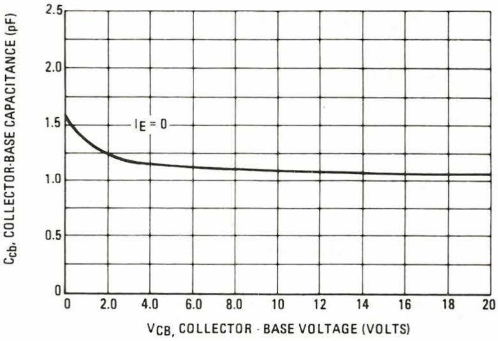


FIGURE 3 – CURRENT-GAIN–BANDWIDTH PRODUCT

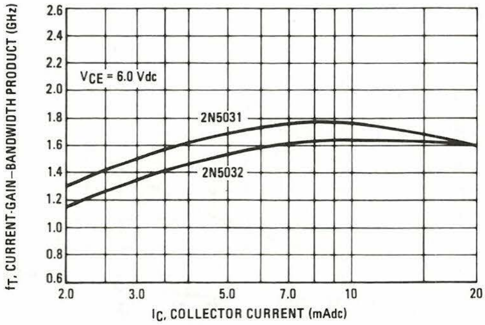


FIGURE 4 – S_{11} AND S_{22}

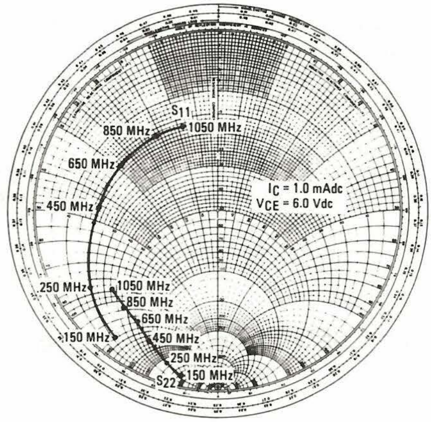


FIGURE 5 – S_{12}

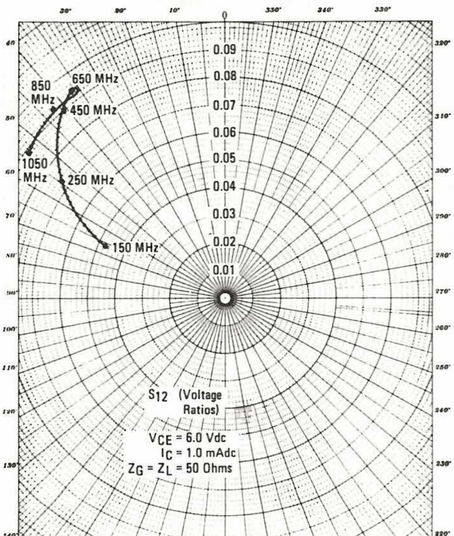


FIGURE 6 – S_{21}

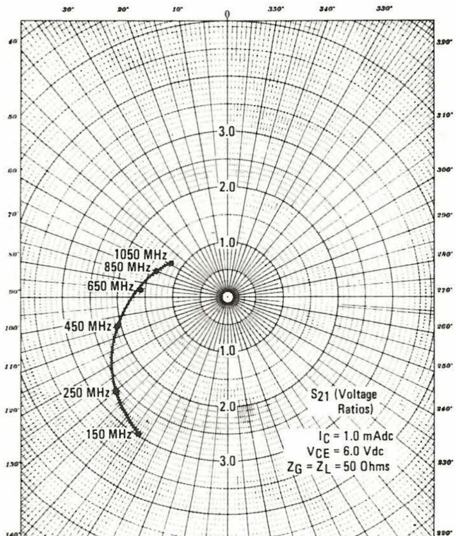


FIGURE 7 – NOISE FIGURE versus FREQUENCY

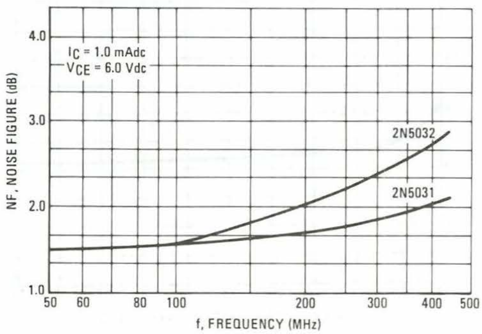


FIGURE 8 – POWER GAIN versus FREQUENCY

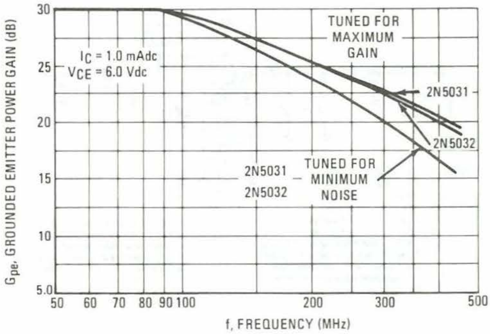


FIGURE 9 – INPUT ADMITTANCE versus FREQUENCY

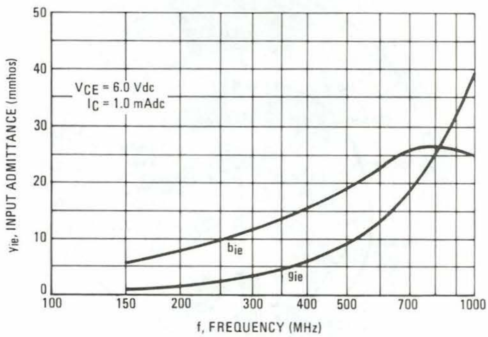


FIGURE 10 – OUTPUT ADMITTANCE versus FREQUENCY

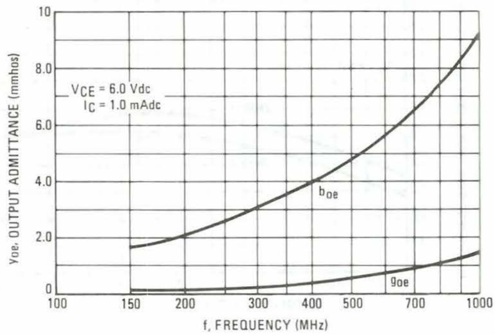


FIGURE 11 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

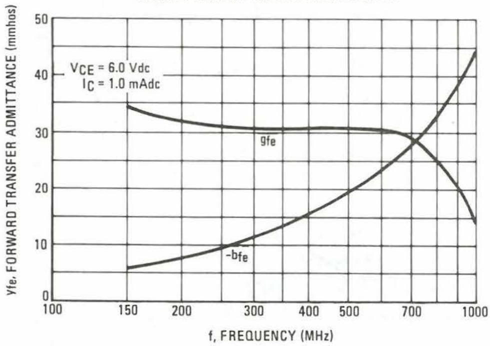
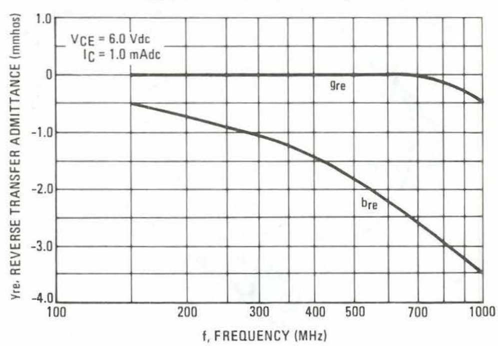


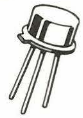
FIGURE 12 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY



7

2N5108

CASE 79-02, STYLE 1
TO-39 (TO-205AD)



HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

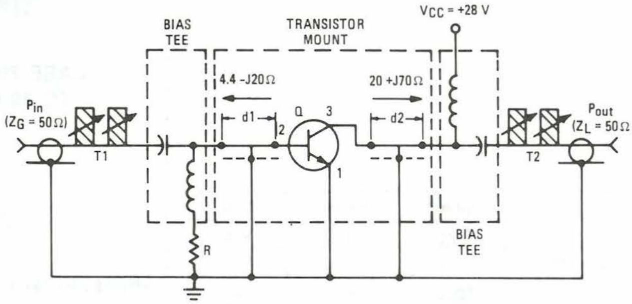
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Emitter Voltage (R_{BE} = 10Ω)	V_{CER}	55	Vdc
Collector-Base Voltage	V_{CBO}	55	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	0.4	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.5 0.02	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, R_{BE} = 10 ohms)	$V_{(BR)CER}$	55	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	55	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	I_{CEO}	—	—	20	μAdc
Collector Cutoff Current (V_{CE} = 50 Vdc, V_{BE} = 0) (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 150°C)	I_{CES}	 — —	 — —	 1.0 10	 μAdc mAdc
ON CHARACTERISTICS					
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	—	—	0.5	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	1200	—	—	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	1.3	3.0	pF
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (Figure 1) (P_{out} = 1.0 W, V_{CC} = 28 Vdc, I_C = 102 mAdc, f = 1.0 GHz)	G_{PE}	5.0	—	—	dB
Power Output (Figure 1) (P_{in} = 316 mW, V_{CE} = 28 Vdc, f = 1.0 Ghz)	P_{out}	1.0	—	—	Watt
Collector Efficiency (Figure 1) (P_{in} = 316 mW, V_{CE} = 28 Vdc, f = 1.0 GHz)	η	35	—	—	%
Power Output (Oscillator) (Figure 2) (V_{CE} = 20 Vdc, V_{EB} = 1.5 Vdc, f = 1.68 GHz) (Minimum Efficiency = 15%)	P_{out}	—	0.3	—	Watt

7

FIGURE 1 — 1 GHz RF AMPLIFIER OUTPUT POWER TEST CIRCUIT

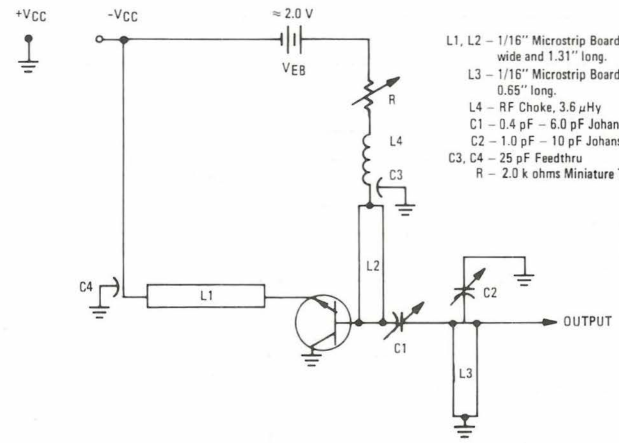


d1: 1" Input line, center conductor width = 0.280"
d2: 1" Output line, center conductor width = 0.125"
Q: 2N5108
R: 3.9 ohms
T1, T2: Microlab Double Stub Tuner, or Equivalent
Bias Tee: Microlab 08N, or Equivalent
Transistor Mount: 1/32" Microstrip board

Note: Impedance measurements are made at transistor socket pins.

7

FIGURE 2 — 1.68 GHz RF OSCILLATOR OUTPUT POWER TEST CIRCUIT



L1, L2 – 1/16" Microstrip Board. Lines are 0.16" wide and 1.31" long.
L3 – 1/16" Microstrip Board. 0.16" wide and 0.65" long.
L4 – RF Choke, 3.6 μHy
C1 – 0.4 pF – 6.0 pF Johanson 4640
C2 – 1.0 pF – 10 pF Johanson 4355
C3, C4 – 25 pF Feedthru
R – 2.0 k ohms Miniature Trim pot

FIGURE 3 — OUTPUT POWER versus INPUT POWER

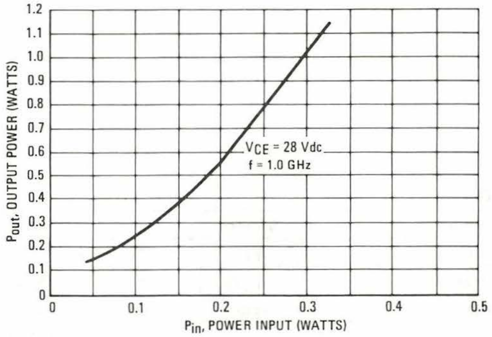


FIGURE 4 — OUTPUT POWER versus FREQUENCY

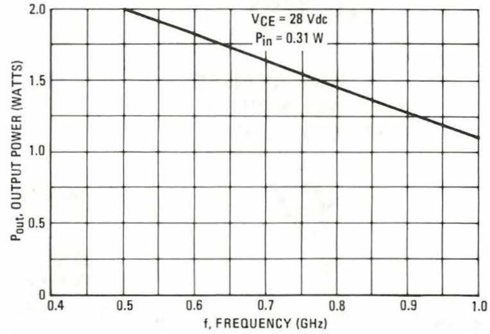


FIGURE 5 — OUTPUT POWER versus COLLECTOR-EMITTER VOLTAGE

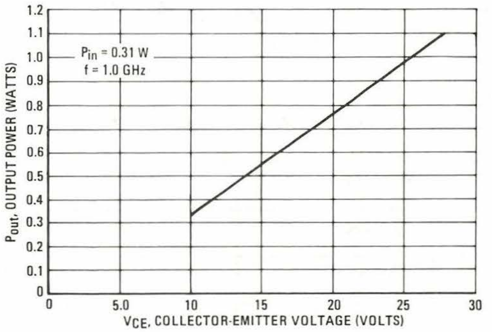


FIGURE 6 — OSCILLATOR OUTPUT POWER versus COLLECTOR CURRENT

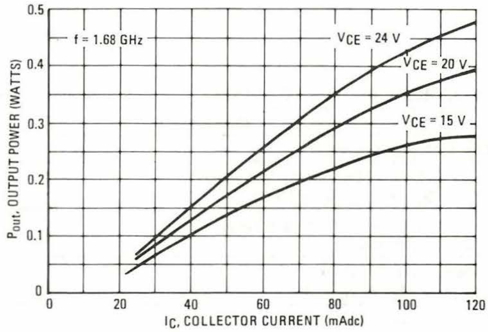


FIGURE 7 CURRENT-GAIN—BANDWIDTH PRODUCT versus CURRENT

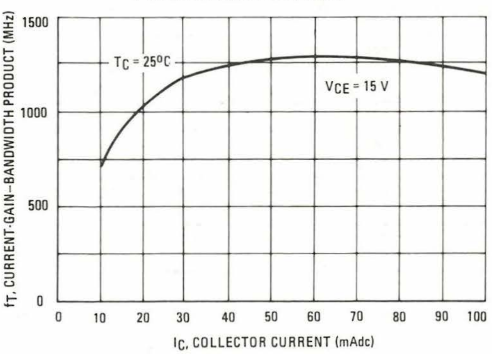
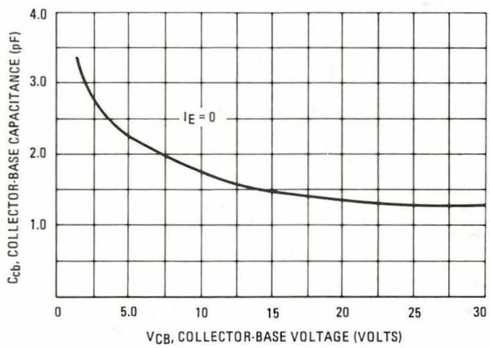


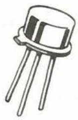
FIGURE 8 COLLECTOR BASE CAPACITANCE versus VOLTAGE



7

2N5109

JAN, JTX, JTXV AVAILABLE
CASE 79-02, STYLE 1
TO-39 (TO-205AD)



HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Base Current	I_B	400	mAdc
Collector Current — Continuous	I_C	400	mAdc
Total Device Dissipation @ $T_C = 75°C$(1) Derate above 25°C	P_D	2.5 20	Watt mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

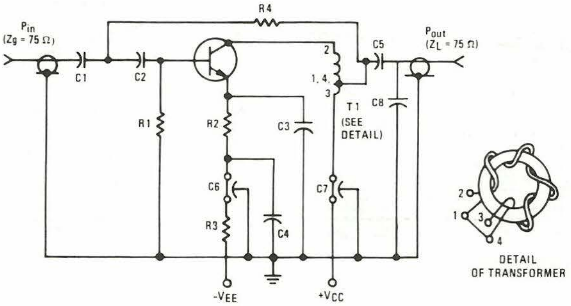
(1) Total Device Dissipation at $T_A = 25°C$ is 1.0 Watt.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 5.0$ mAdc, $R_{BE} = 10\ \Omega$)	$V_{(BR)CER}$	40	—	—	Vdc
Collector-Emitter Sustaining Voltage ($I_C = 5.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 15$ Vdc, $I_B = 0$)	I_{CEO}	—	—	20	μAdc
Collector Cutoff Current ($V_{CE} = 15$ Vdc, $V_{BE} = -1.5$ V, $T_C = 150°C$) ($V_{CE} = 35$ Vdc, $V_{BE} = -1.5$ V)	I_{CEX}	 — —	 — —	 5.0 5.0	 mAdc mAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	100	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 360$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 50$ mAdc, $V_{CE} = 15$ Vdc)	h_{FE}	 5.0 40	 — —	 — 120	 — —
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 15$ Vdc, f = 200 MHz)	f_T	1200	—	—	MHz
Collector-Base Capacitance ($V_{CB} = 15$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	—	1.8	3.5	pF
Noise Figure ($I_C = 10$ mAdc, $V_{CE} = 15$ Vdc, f = 200 MHz)	NF	—	3.0	—	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Voltage Gain (Figure 1) ($I_C = 50$ mAdc, $V_{CC} = 15$ Vdc, f = 50 to 216 MHz)	G_{ve}	11	—	—	dB
Power Input (Figure 2) ($I_C = 50$ mAdc, $V_{CC} = 15$ Vdc, $R_S = 50$ ohms, $P_{out} = 1.26$ mW, f = 200 MHz)	P_{in}	—	—	0.1	mW

( ) Pulsed thru a 25 mH Inductor; 50% Duty Cycle.

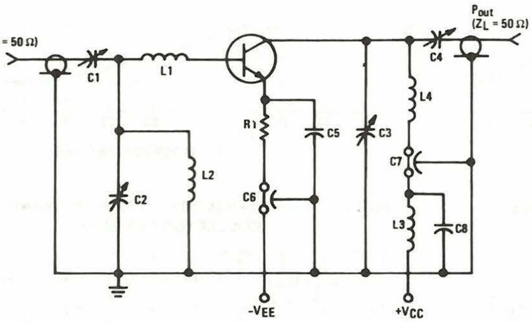
FIGURE 1 – RF AMPLIFIER FOR VOLTAGE GAIN TEST CIRCUIT



C1, C2, C3, C5 0.002 μF
C4 0.03 μF
C6, C7 1500 pF
C8 18 pF
R1 4.7 k, 1/4 W
R2 6.8 Ω, 1/2 W

R3 330 Ω, 1 W
R4 200 Ω, 1/4 W
T1 4 Turns #30 Wire
Bifilar wound on "Indiana General"
Core #CF-102-Q1, or equivalent

FIGURE 2 – 200 MHz TEST CIRCUIT



C1, C2, C3 1.0 – 30 pF
C4 1.0 – 20 pF
C5 10,000 pF
C6, C7 1,000 pF
C8 0.01 μF

L1 4-1/2 turns, No. 22 wire, 3/16" I.D.
L4 3-1/2 turns, No. 22 wire, 3/16" I.D.
L2, L3 0.82 μH RFC
R1 240 OHMS, 2 WATTS

FIGURE 3 – CURRENT-GAIN – BANDWIDTH PRODUCT

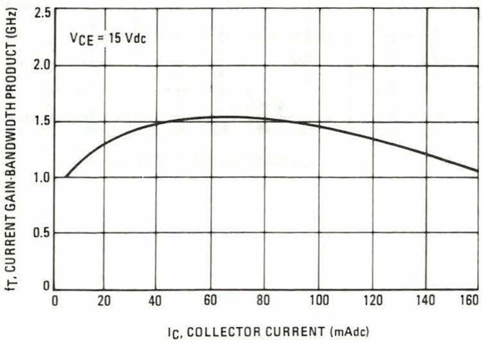


FIGURE 4 – COLLECTOR-BASE TIME CONSTANT

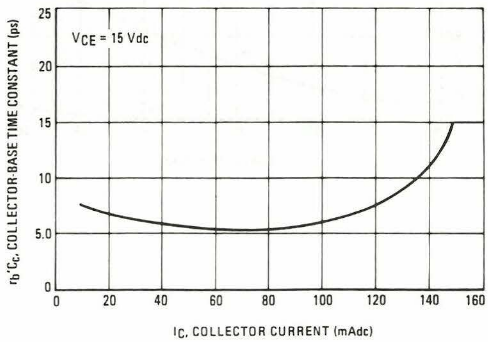


FIGURE 5 – SATURATION VOLTAGES

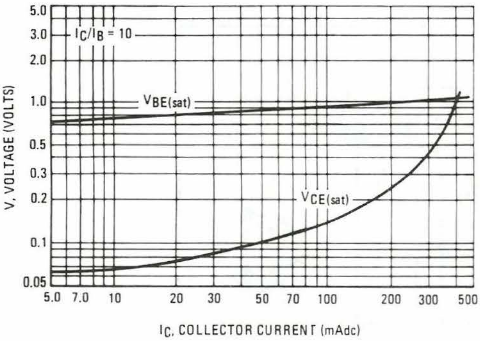


FIGURE 6 – CAPACITANCES versus REVERSE VOLTAGE

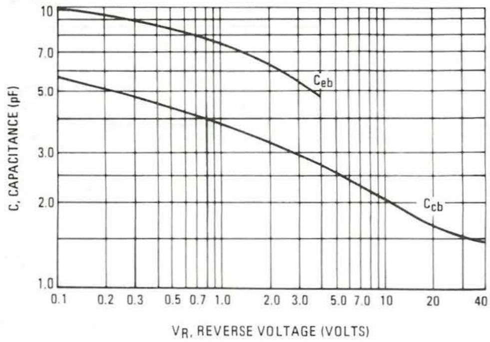


FIGURE 7 – INPUT ADMITTANCE versus FREQUENCY

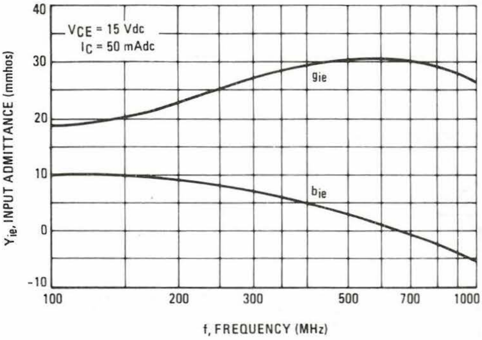


FIGURE 8 – INPUT ADMITTANCE versus COLLECTOR CURRENT

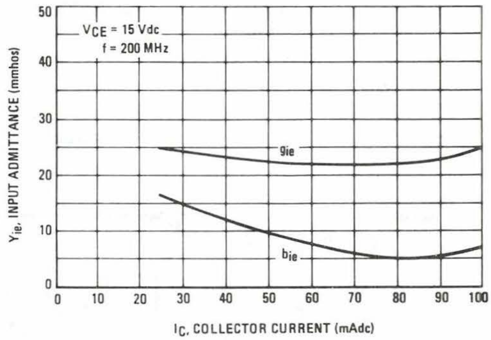


FIGURE 9 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY

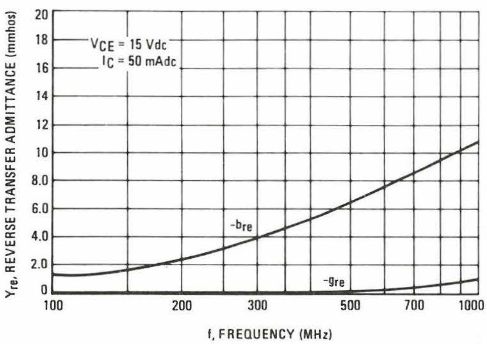
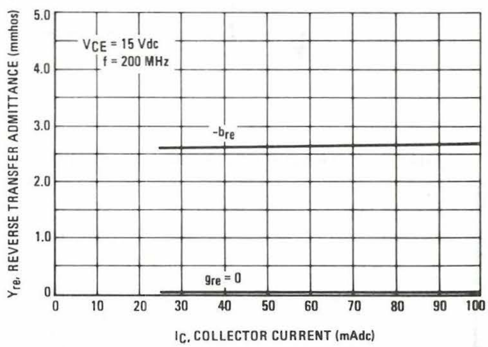


FIGURE 10 – REVERSE TRANSFER ADMITTANCE versus COLLECTOR CURRENT



7

FIGURE 11 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

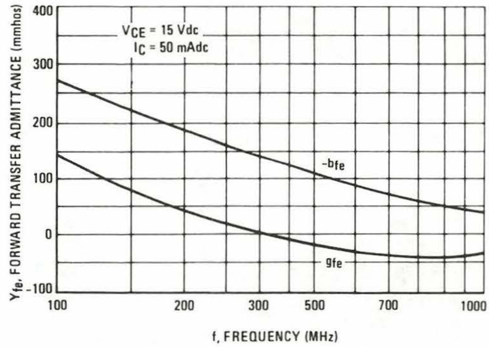


FIGURE 12 – FORWARD TRANSFER ADMITTANCE versus COLLECTOR CURRENT

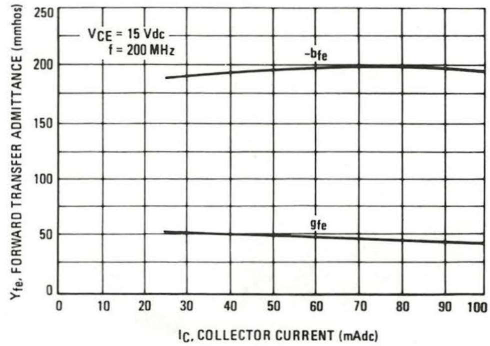


FIGURE 13 – OUTPUT ADMITTANCE versus FREQUENCY

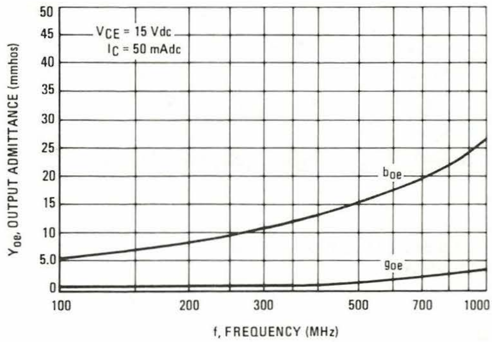


FIGURE 14 – OUTPUT ADMITTANCE versus COLLECTOR CURRENT

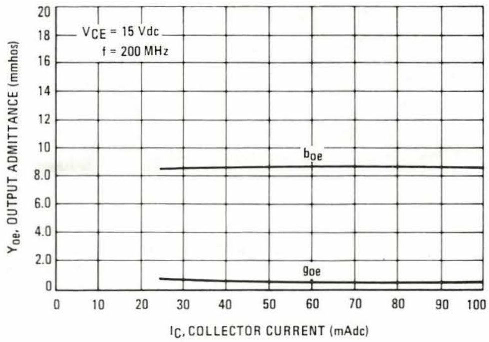


FIGURE 15 – INPUT REFLECTION COEFFICIENT versus FREQUENCY

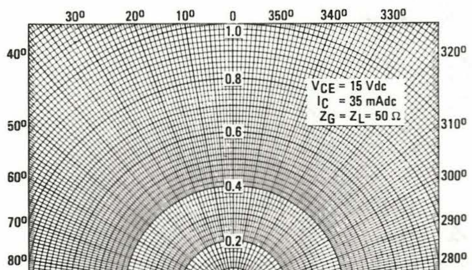
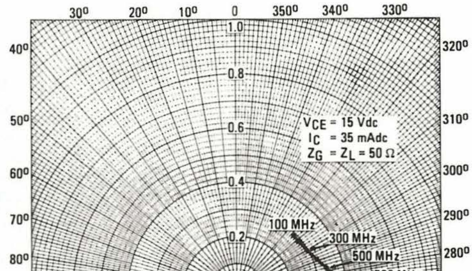


FIGURE 16 – OUTPUT REFLECTION COEFFICIENT versus FREQUENCY



7

FIGURE 17 – REVERSE TRANSMISSION COEFFICIENT versus FREQUENCY

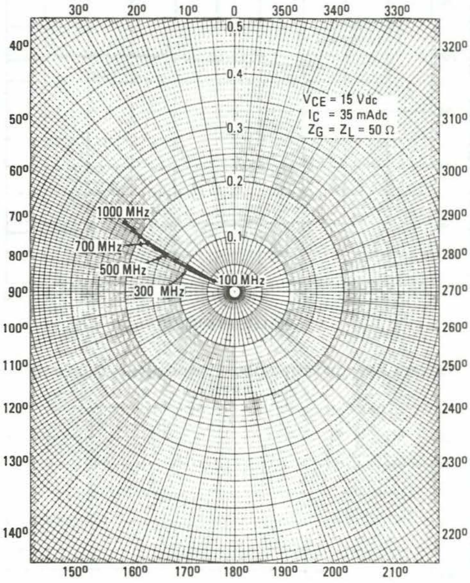


FIGURE 18 – FORWARD TRANSMISSION COEFFICIENT versus FREQUENCY

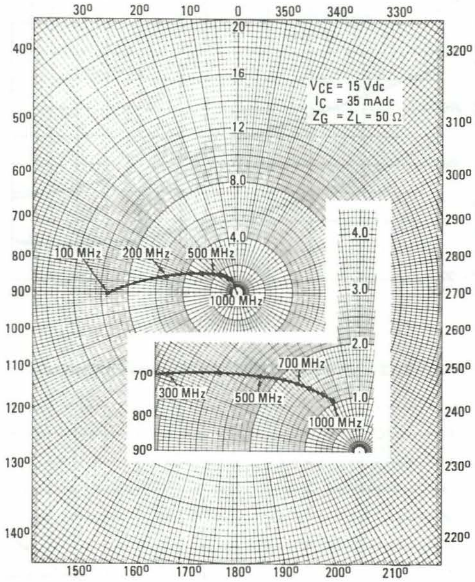
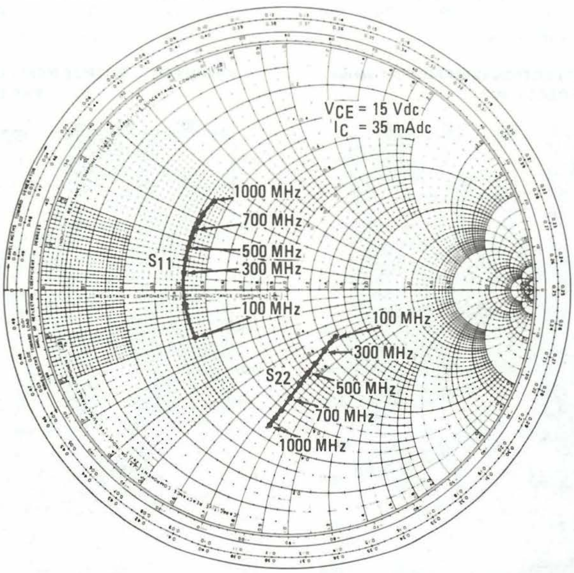


FIGURE 19 – INPUT REFLECTION COEFFICIENT AND OUTPUT REFLECTION COEFFICIENT versus FREQUENCY



7

2N5160

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

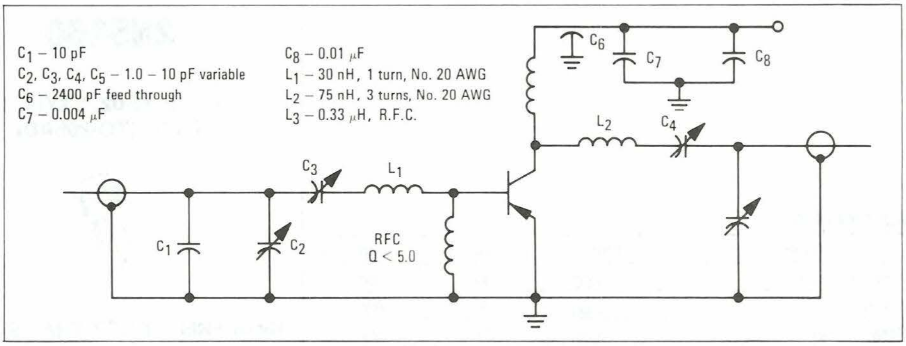
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current	I_C	0.4	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, I_B = 0)	I_{CEO}	—	—	20	μAdc
Collector Cutoff Current (V_{CE} = 60 Vdc, V_{BE} = 0)	I_{CES}	—	—	0.1	mAdc
Collector Cutoff Current (V_{CB} = 28 Vdc, I_E = 0)	I_{CBO}	—	—	1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10	—	—	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	500	900	—	MHz
Collector-Base Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{cb}	—	2.5	4.0	pF
FUNCTIONAL TEST					
Amplifier Power Gain (V_{CE} = 28 Vdc, P_{in} = 0.16 Watt, f = 400 MHz) (V_{CE} = 28 Vdc, P_{in} = 50 mW, f = 175 MHz)	G_{pe}	 8.0 —	 8.8 14.5	 — —	dB
Power Output (V_{CE} = 28 Vdc, P_{in} = 0.16 Watt, f = 400 MHz) (V_{CE} = 28 Vdc, P_{in} = 50 mW, f = 175 MHz)	P_{out}	 1.0 —	 1.2 1.4	 — —	Watt
Collector Efficiency (V_{CE} = 28 Vdc, P_{in} = 0.16 Watt, f = 400 MHz)	η	45	55	—	%

7

FIGURE 1 – 400-MHz TEST CIRCUIT



POWER OUTPUT

FIGURE 2

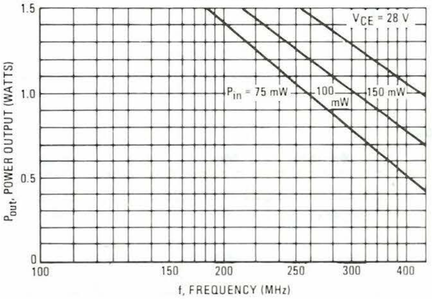
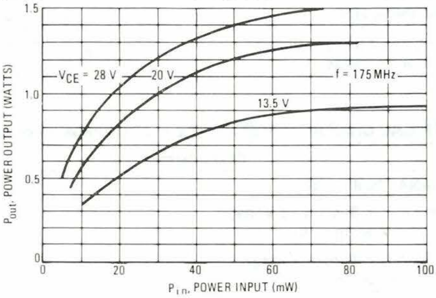


FIGURE 3



PARALLEL INPUT

FIGURE 4

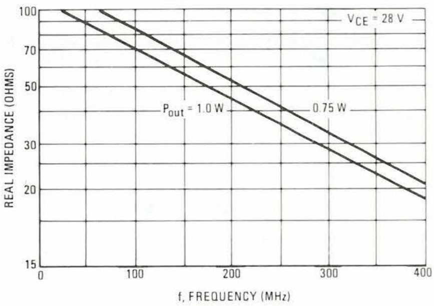


FIGURE 5

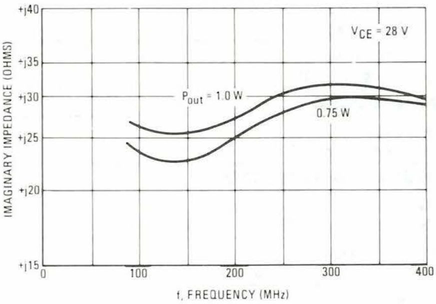


FIGURE 6 – PARALLEL OUTPUT CAPACITANCE versus FREQUENCY

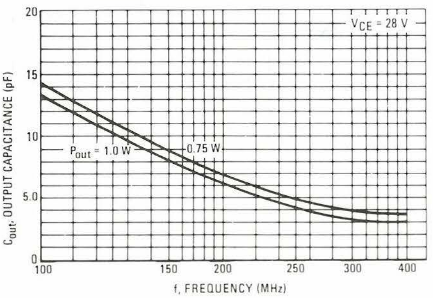
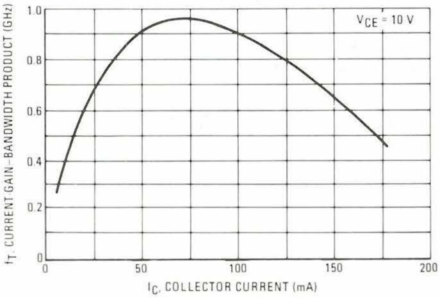


FIGURE 7 – CURRENT-GAIN–BANDWIDTH PRODUCT versus COLLECTOR CURRENT



2N5179

CASE 20-03, STYLE 10
TO-72 (TO-206AF)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage Applicable 1.0 to 2.0 mAdc	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	2.5	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	200 1.14	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	300 1.71	mW mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

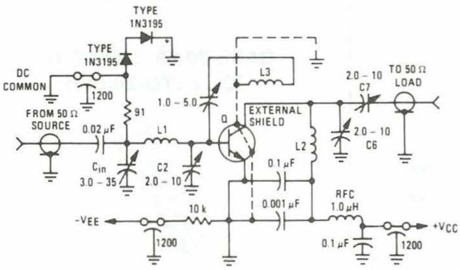
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage ($I_C = 3.0$ mAdc, $I_B = 0$)	$V_{CEO(sus)}$	12	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.001$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	20	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.01$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	2.5	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$) ($V_{CB} = 15$ Vdc, $I_E = 0$, $T_A = 150°C$)	I_{CBO}	 — —	 0.02 1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 3.0$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	25	250	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	—	1.0	Vdc
SMALL SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product(1) ($I_C = 5.0$ mAdc, $V_{CE} = 6.0$ Vdc, f = 100 MHz)	f_T	900	2000	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 0.1 to 1.0 MHz)	C_{cb}	—	1.0	pF
Small Signal Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 6.0$ Vdc, f = 1.0 kHz)	h_{fe}	25	300	—
Collector Base Time Constant ($I_E = 2.0$ mAdc, $V_{CB} = 6.0$ Vdc, f = 31.9 MHz)	$rb'C_c$	3.0	14	ps
Noise Figure (Figure 1) ($I_C = 1.5$ mAdc, $V_{CE} = 6.0$ Vdc, $R_S = 50$ ohms, f = 200 MHz)	NF	—	4.5	dB
FUNCTIONAL TEST				
Common-Emitter Amplifier Power Gain (Figure 1) ($V_{CE} = 6.0$ Vdc, $I_C = 5.0$ mAdc, f = 200 MHz)	G_{pe}	15	—	dB
Power Output (Figure 2) ($V_{CB} = 10$ Vdc, $I_E = 12$ mAdc, f≥500 MHz)	P_{out}	20	—	mW

(1) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

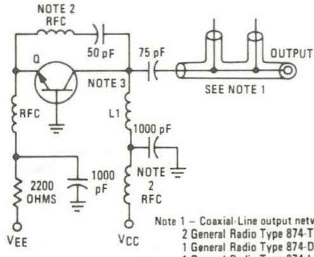
7

FIGURE 1 – 200 MHz AMPLIFIER POWER GAIN AND NOISE FIGURE CIRCUIT



L1 1-3/4 Turns, #18 AWG, 0.5" L, 0.5" Diameter
L2 2 Turns, #16 AWG, 0.5" L, 0.5" Diameter
L3 2 Turns, #13 AWG, 0.25" L, 0.5" Diameter (Position 1/4" from L2)

FIGURE 2 – 500 MHz OSCILLATOR CIRCUIT



Note 1 – Coaxial-Line output network consisting of:
2 General Radio Type 874-TEE or equivalent
1 General Radio Type 874-D20 Adjustable Stub or equivalent
1 General Radio Type 874-LA Adjustable Line or equivalent
1 General Radio Type 874-WN3 Short-circuit termination or equivalent
Note 2 – RFC = 0.2 μH Ohmite #2-460 or equivalent
Note 3 – Lead Number 4 (case) floating
L1 – 2 turns #16 AWG wire, 3/8 inch OD, 1-1/4 inch long
Q = 2N5179

FIGURE 3 – NOISE FIGURE versus FREQUENCY

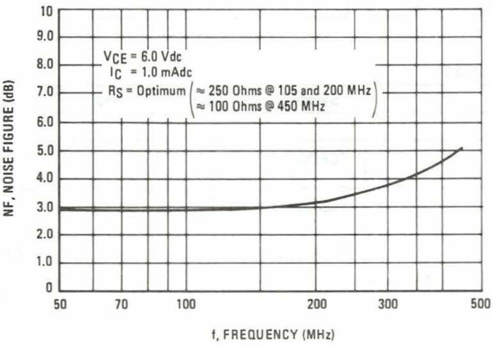


FIGURE 4 – NOISE FIGURE versus SOURCE RESISTANCE and COLLECTOR CURRENT

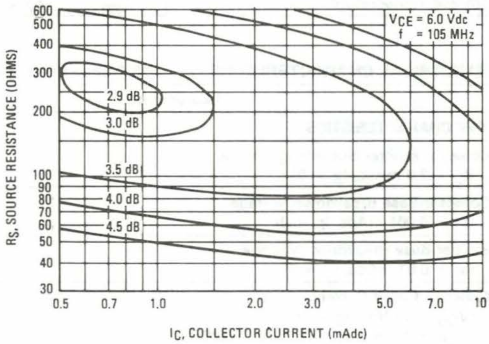
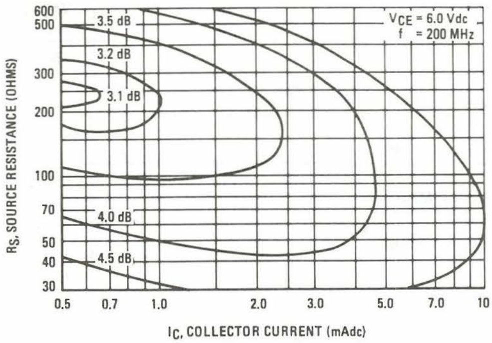


FIGURE 5 – NOISE FIGURE versus SOURCE RESISTANCE and COLLECTOR CURRENT



7

FIGURE 6 – CURRENT-GAIN-BANDWIDTH PRODUCT

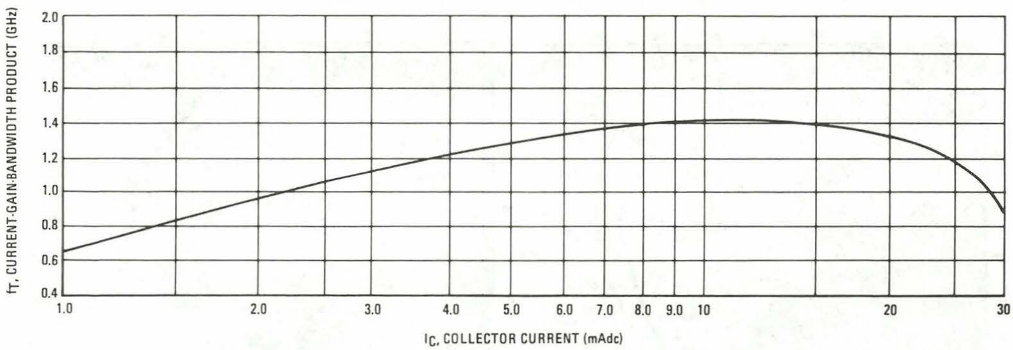


FIGURE 7 – INPUT ADMITTANCE versus FREQUENCY

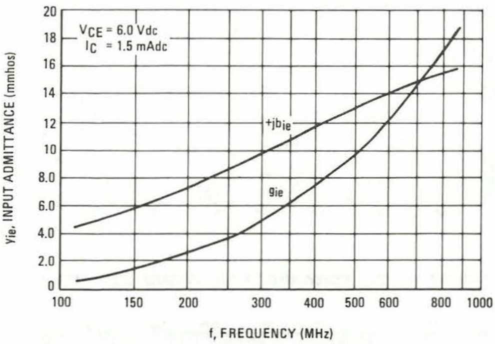


FIGURE 8 – OUTPUT ADMITTANCE versus FREQUENCY

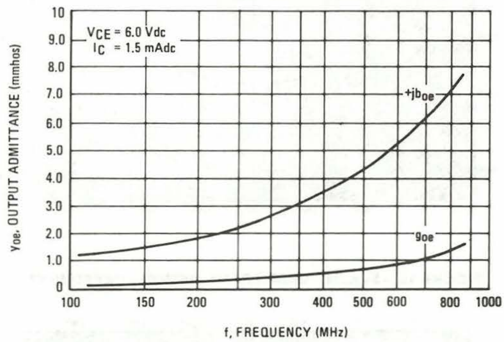


FIGURE 9 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

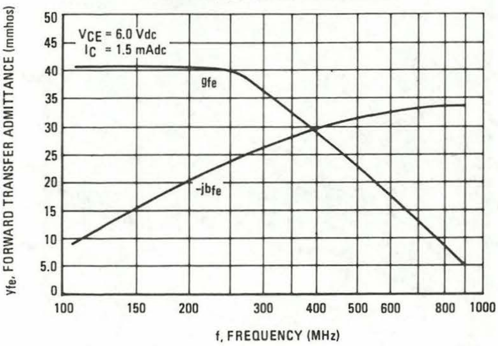
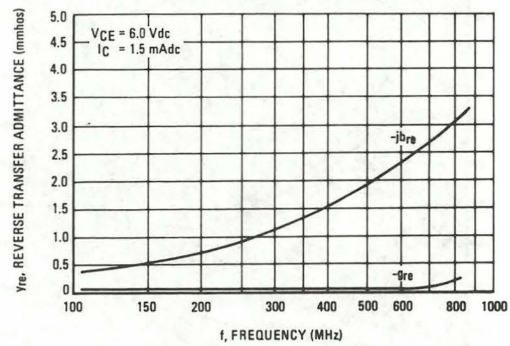


FIGURE 10 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY



7

FIGURE 11— S_{11}, INPUT REFLECTION COEFFICIENT

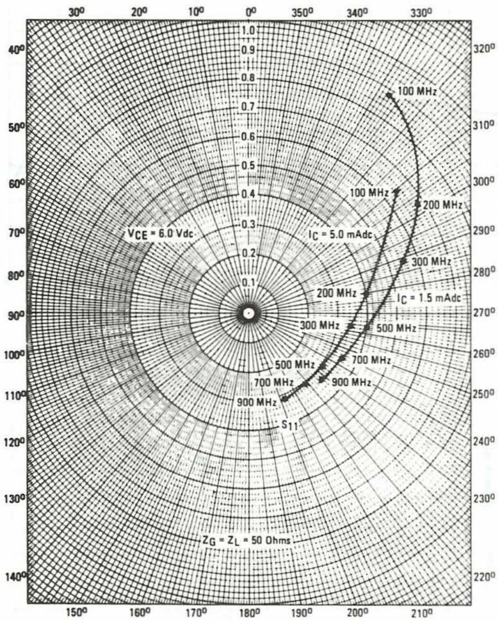
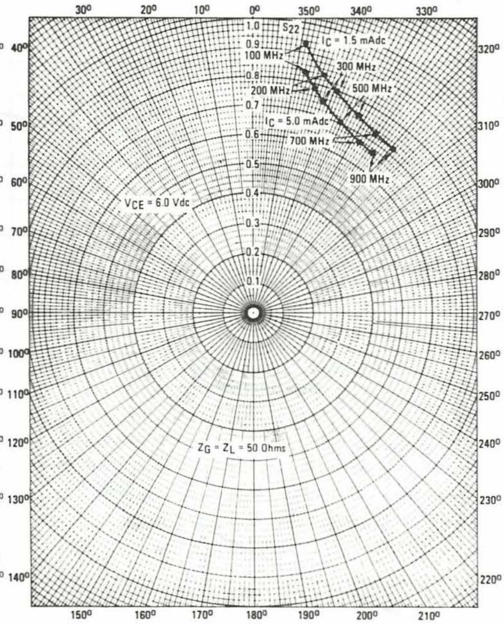


FIGURE 12—S_{22}, OUTPUT REFLECTION COEFFICIENT



7

FIGURE 13 —S_{12}, REVERSE TRANSMISSION COEFFICIENT

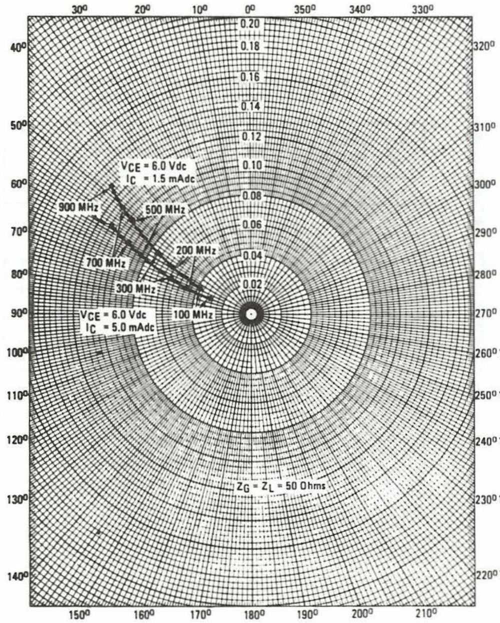


FIGURE 14 —S_{21}, FORWARD TRANSMISSION COEFFICIENT

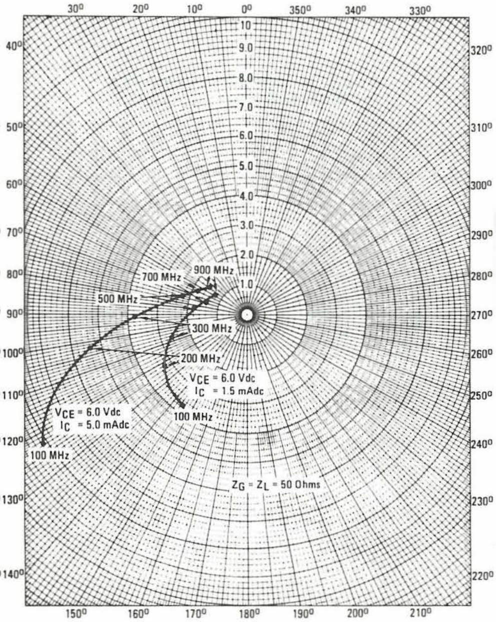
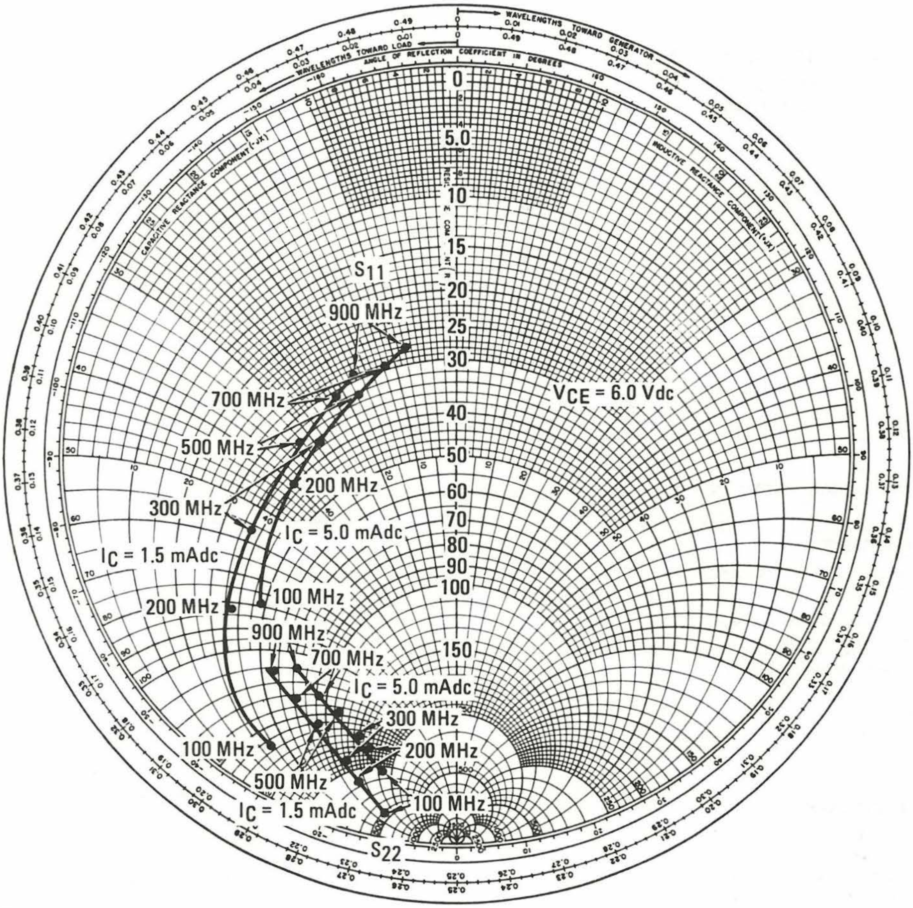


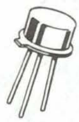
FIGURE 15 — S_{11}, INPUT REFLECTION COEFFICIENT AND S_{22}, OUTPUT REFLECTION COEFFICIENT



7

2N5583

JAN, JTX, JTXV AVAILABLE
CASE 79-02, STYLE 1
TO-39 (TO-205AD)



HIGH FREQUENCY TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current ($V_{EB} = 2.0$ Vdc, $I_C = 0$)	I_{EBO}	—	—	0.5	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) ($I_C = 40$ mAdc, $V_{CE} = 2.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 2.0$ Vdc) ($I_C = 300$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	 20 25 15	 40 40 22	 — 100 —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 100$ mAdc, $I_B = 10$ mAdc)	$V_{CE(sat)}$	—	0.6	0.8	Vdc
Base-Emitter On Voltage(1) ($I_C = 100$ mAdc, $V_{CE} = 2.0$ Vdc)	$V_{BE(on)}$	—	0.84	1.8	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 40$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz) ($I_C = 100$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	 1000 1300	 1300 1500	 — —	MHz
Collector-Base Capacitance ($V_{CB} = 15$ Vdc, $I_E = 0$, f = 100 kHz)	C_{cb}	—	2.5	5.0	pF
Emitter-Base Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)	C_{eb}	—	18	35	pF
Collector Base Time Constant ($I_C = 50$ mAdc, $V_{CB} = 10$ Vdc, f = 63.6 MHz)	$rb'C_c$	—	8.0	—	ps
SWITCHING CHARACTERISTICS (FIGURE 10)					
Turn-On Delay Time ($V_{CC} = 31.4$ Vdc, $I_C = 150$ mAdc, $R_C = 160$ Ohms, $R_E = 26.6$ Ohms)	t_d	—	1.0	—	ns
Rise Time ($V_{CC} = 31.4$ Vdc, $I_C = 150$ mAdc, $R_C = 160$ Ohms, $R_E = 26.6$ Ohms)	t_r	—	2.1	—	ns
Fall Time ($V_{CC} = 31.4$ Vdc, $I_C = 150$ mAdc, $R_C = 160$ Ohms, $R_E = 26.6$ Ohms)	t_f	—	1.8	—	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – DC CURRENT GAIN

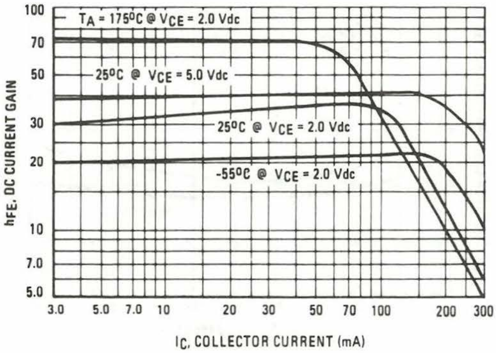


FIGURE 2 – COLLECTOR SATURATION REGION

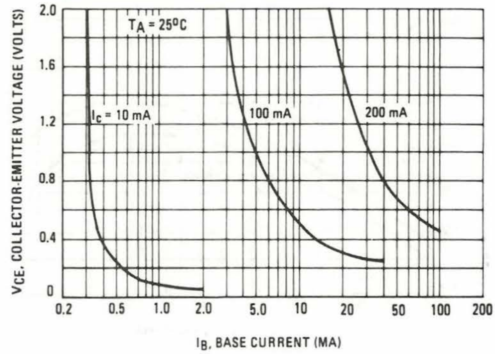


FIGURE 3 – "ON" VOLTAGES

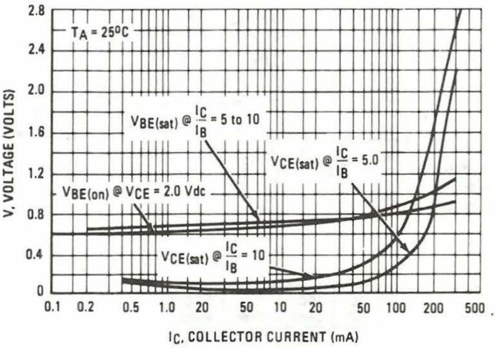


FIGURE 4 – COLLECTOR CURRENT versus BASE VOLTAGE

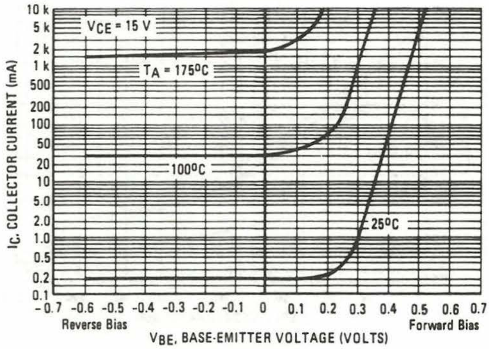


FIGURE 5 – CAPACITANCES

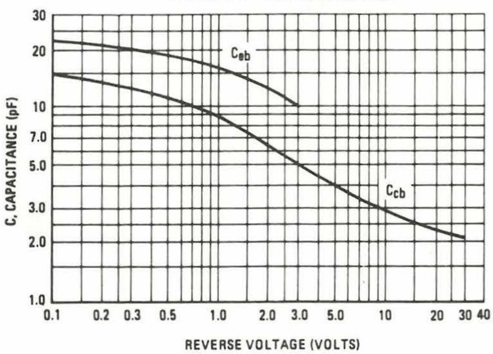


FIGURE 6 – TEMPERATURE COEFFICIENTS

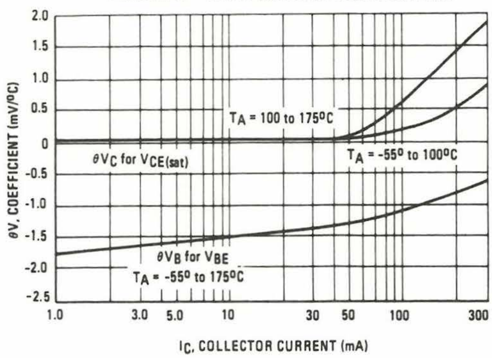


FIGURE 7 – CURRENT-GAIN–BANDWIDTH PRODUCT

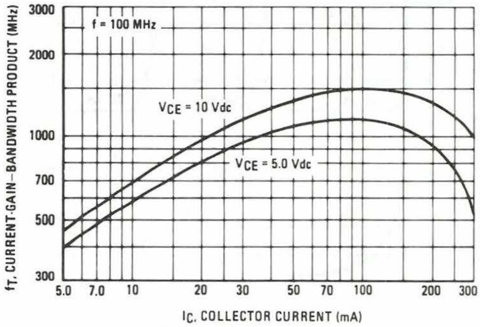


FIGURE 8 – COLLECTOR-BASE TIME CONSTANT

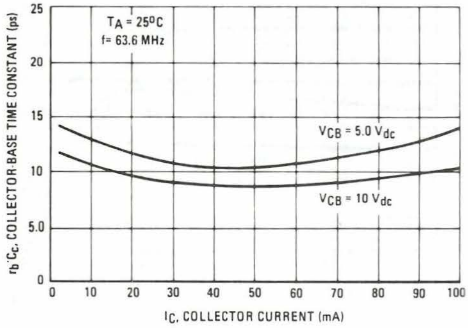


FIGURE 9 – SWITCHING TIMES

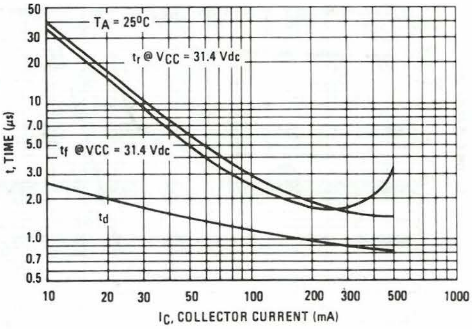
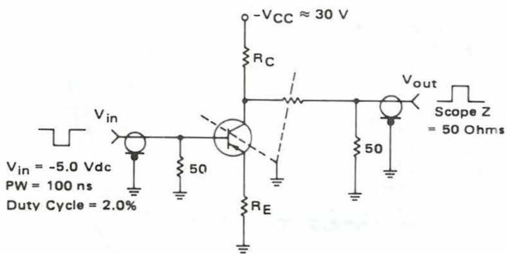


FIGURE 10 – SWITCHING TIMES TEST CIRCUIT



I_C mA	R_C Ohms	R_E Ohms	V_{CC} Volts
50	526	80	34.4
150	160	26.6	31.4
300	78	13.3	30.6
500	46.5	8.0	30.3

2N5829 For Specifications see 2N4957 Data.

2N5835
2N5836
2N5837

2N5835
CASE 20-03, STYLE 10
TO-72 (TO-206AF)

2N5836, 2N5837
CASE 26-03, STYLE 1
TO-46 (TO-206AB)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	2N5835	2N5836	2N5837	Unit
Collector-Emitter Voltage	V_{CEO}	10	10	5.0	Vdc
Collector-Base Voltage	V_{CBO}	15	15	10	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	3.5	3.5	Vdc
Collector Current — Continuous	I_C	15	200	300	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	 200 1.14	 — —	 — —	 mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	 — —	 2.0 11.43	 2.0 11.43	 Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200			°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0) (I_C = 100 μAdc, I_E = 0)	 2N5835 2N5836 2N5837	$V_{(BR)CBO}$	 15 15 10	 — — —	 — — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 7.5 Vdc, I_E = 0) (V_{CB} = 10 Vdc, I_E = 0) (V_{CB} = 5.0 Vdc, I_E = 0)	 2N5835 2N5836 2N5837	I_{CBO}	 — — —	 — — —	 0.01 10 10	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	—	100	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 10 mAdc, V_{CE} = 6.0 Vdc) (I_C = 50 mAdc, V_{CE} = 6.0 Vdc) (I_C = 100 mAdc, V_{CE} = 3.0 Vdc)	 2N5835 2N5836 2N5837	h_{FE}	 25 25 25	 — — —	 — — —	—
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 6.0 Vdc) (I_C = 50 mAdc, V_{CE} = 6.0 Vdc) (I_C = 100 mAdc, V_{CE} = 3.0 Vdc)	 2N5835 2N5836 2N5837	$V_{BE(on)}$	 — — —	 — — —	 0.9 0.9 0.9	Vdc
SMALL SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(1) (I_C = 10 mAdc, V_{CE} = 6.0 Vdc, f = 200 MHz) (I_C = 50 mAdc, V_{CE} = 6.0 Vdc, f = 200 MHz) (I_C = 100 mAdc, V_{CE} = 3.0 Vdc, f = 200 MHz)	 2N5835 2N5836 2N5837	f_T	 2.5 2.0 1.7	 — — —	 — — —	GHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 to 1.0 MHz) (V_{CB} = 5.0 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	 2N5835 2N5836 2N5837	C_{cb}	 — — —	 — — —	 0.8 3.5 5.0	pF
Collector Base Time Constant(2) (I_C = 10 mAdc, V_{CE} = 6.0 Vdc, f = 63.6 MHz) (I_C = 50 mAdc, V_{CE} = 6.0 Vdc, f = 63.6 MHz) (I_C = 100 mAdc, V_{CE} = 3.0 Vdc, f = 63.6 MHz)	 2N5835 2N5836 2N5837	$r_b'C_c$	 — — —	 5.0 6.0 6.0	 — — —	ps

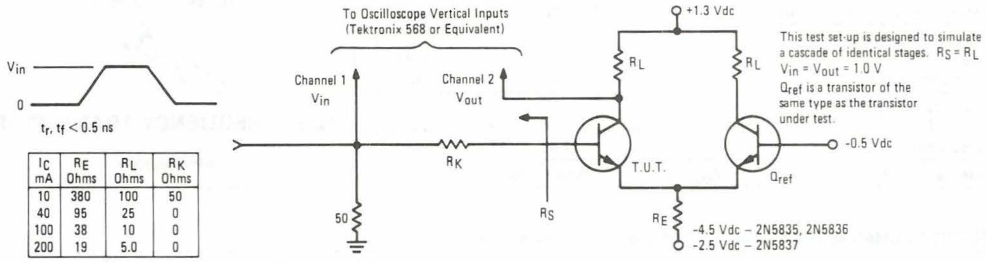
7

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
SWITCHING CHARACTERISTICS(2)						
Rise Time (Figure 1)		t_r				ns
(I_C = 10 mAdc)	2N5835		—	250	—	
(I_C = 40 mAdc)	2N5836		—	320	—	
(I_C = 100 mAdc)	2N5837		—	650	—	

(1) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.
(2) Typical values shown in addition to JEDEC Registered Data.

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



I_C mA	R_E Ohms	R_L Ohms	R_K Ohms
10	380	100	50
40	95	25	0
100	38	10	0
200	19	5.0	0

FIGURE 2 — SWITCHING TIME

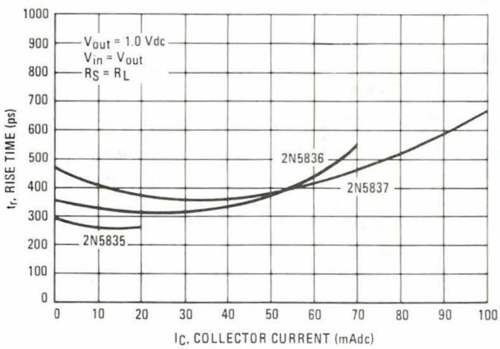


FIGURE 3 — CURRENT-GAIN—BANDWIDTH PRODUCT

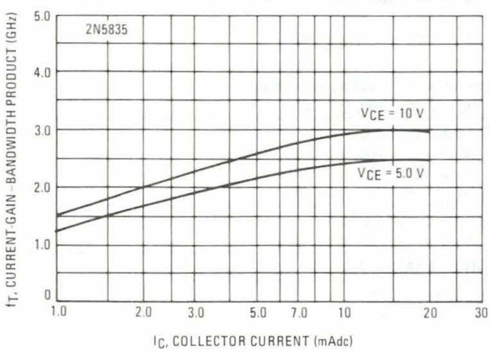


FIGURE 4 — CURRENT-GAIN—BANDWIDTH PRODUCT

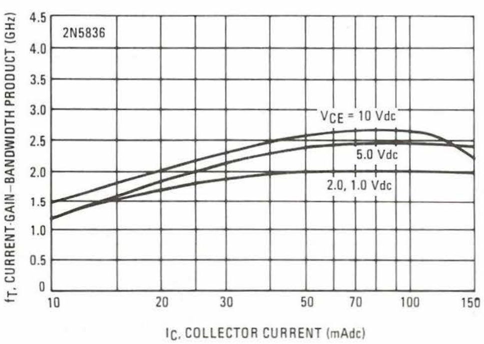


FIGURE 5 — CURRENT-GAIN—BANDWIDTH PRODUCT

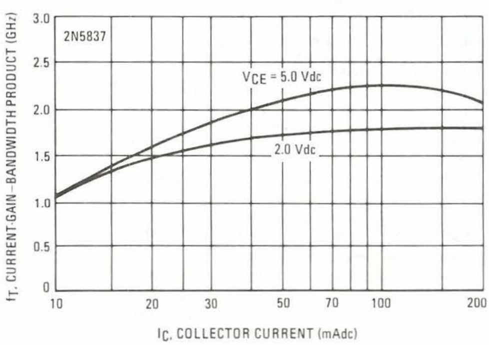


FIGURE 6 – COLLECTOR-BASE TIME CONSTANT

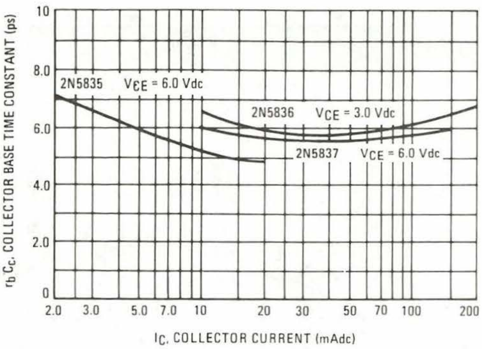
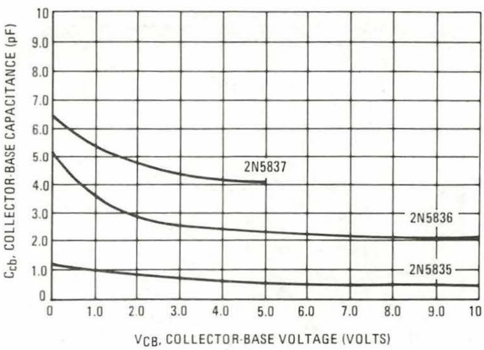


FIGURE 7 – COLLECTOR-BASE CAPACITANCE



2N5835 SCATTERING PARAMETERS

(I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, Z_G = Z_L = 50 Ohms)

FIGURE 8 – S_{11}, INPUT REFLECTION COEFFICIENT

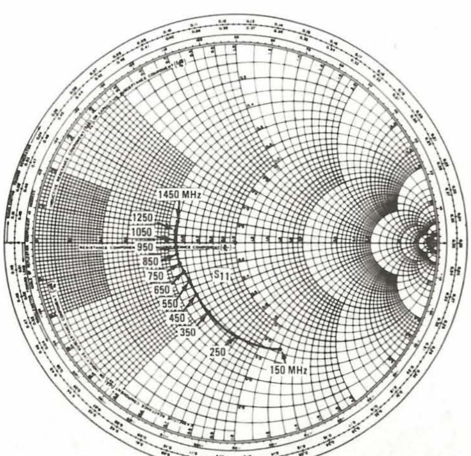


FIGURE 9 – S_{22}, OUTPUT REFLECTION COEFFICIENT

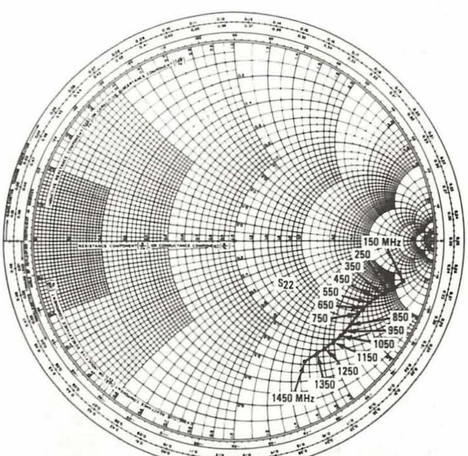


FIGURE 10 – S_{12}, REVERSE TRANSMISSION COEFFICIENT

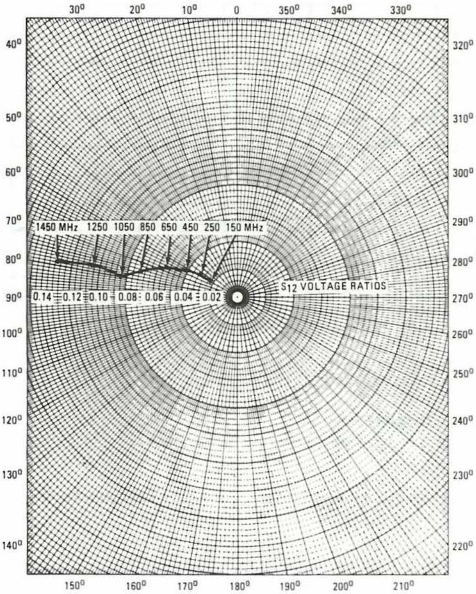
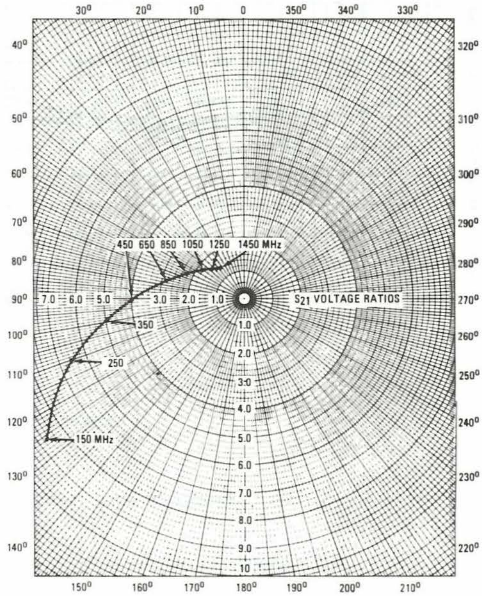


FIGURE 11 – S_{21}, FORWARD TRANSMISSION COEFFICIENT



7

2N5836 SCATTERING PARAMETERS

(I_C = 100 mAdc, V_{CE} = 10 Vdc, Z_G = Z_L = 50 Ohms)

FIGURE 12 – S_{11}, INPUT REFLECTION COEFFICIENT

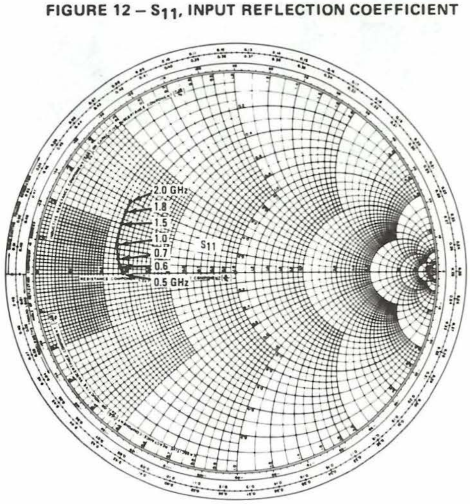


FIGURE 13 – S_{22}, OUTPUT REFLECTION COEFFICIENT

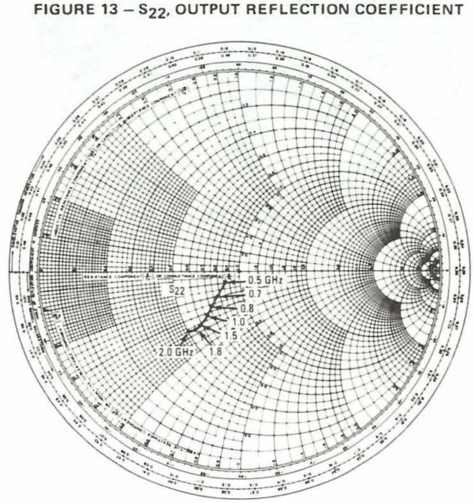


FIGURE 14 – S_{12}, REVERSE TRANSMISSION COEFFICIENT

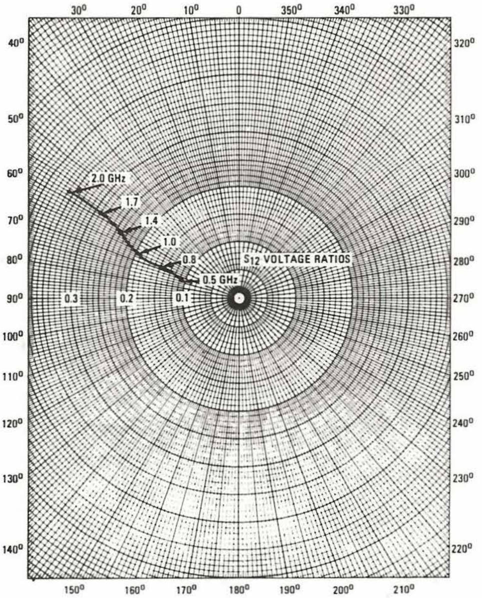
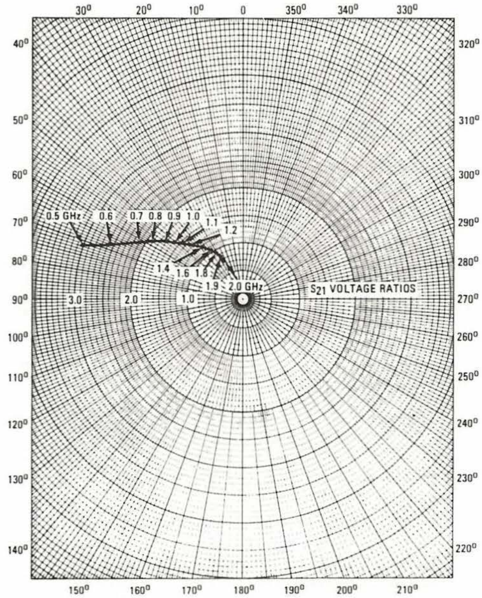


FIGURE 15 – S_{21}, FORWARD TRANSMISSION COEFFICIENT



2N5837 SCATTERING PARAMETERS
(I_C = 100 mAdc, V_{CE} = 3.0 Vdc, Z_G = Z_L = 50 Ohms)

FIGURE 16 – S_{11}, INPUT REFLECTION COEFFICIENT

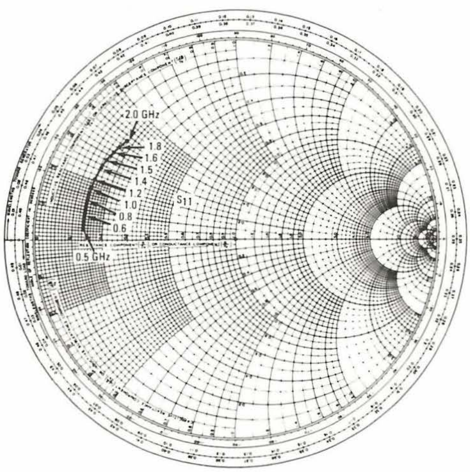
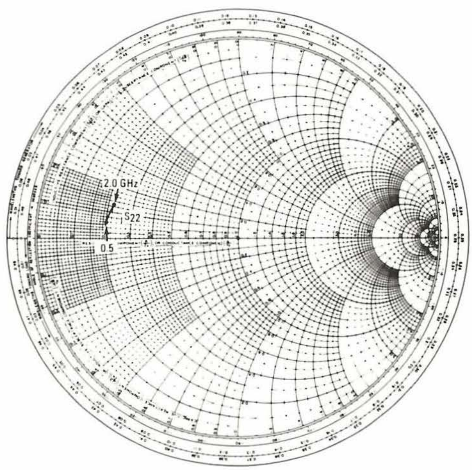


FIGURE 17 – S_{22}, OUTPUT REFLECTION COEFFICIENT



7

FIGURE 18 – S_{12}, REVERSE TRANSMISSION COEFFICIENT

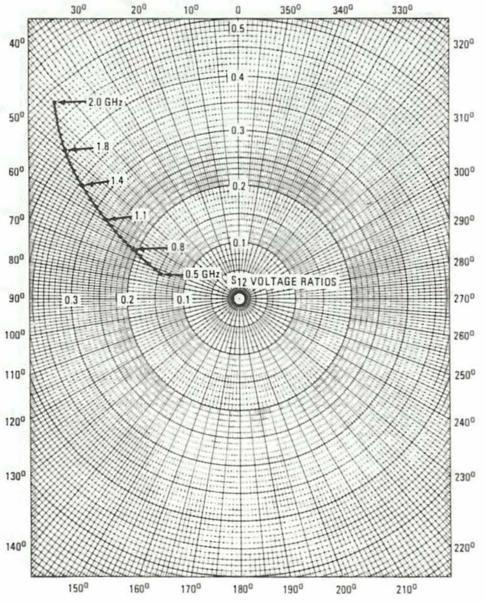
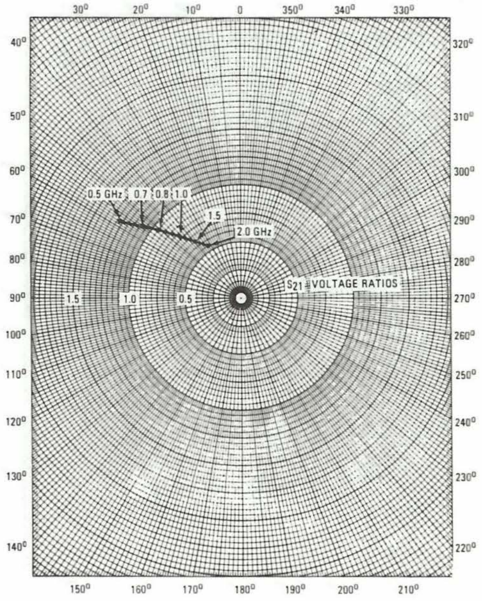


FIGURE 19 – S_{21}, FORWARD TRANSMISSION COEFFICIENT



7

2N5943

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	400	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.7	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.5 0.02	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, I_B = 0)	I_{CEO}	—	—	50	μAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	10	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 15 Vdc)	h_{FE}	25	—	300	—
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	—	0.15	0.2	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	—	0.88	1.0	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 25 mAdc, V_{CE} = 15 Vdc, f = 200 MHz) (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz) (I_C = 100 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	 1000 1200 1000	 1350 1550 1425	 — 2400 —	MHz
Collector-Base Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	1.0	1.6	2.5	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{eb}	—	8.4	15	pF
Small Signal Current Gain (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 1.0 kHz)	h_{fe}	25	—	350	—
Collector Base Time Constant (I_E = 50 mAdc, V_{CB} = 15 Vdc, f = 31.8 MHz)	$r_b'C_c$	2.0	5.5	20	ps
Noise Figure (I_C = 30 mAdc, V_{CE} = 15 Vdc, f = 200 MHz) (Figure 1) (I_C = 35 mAdc, V_{CE} = 15 Vdc, f = 200 MHz) (Figure 6)	NF	 — —	 3.4 6.8	 — 8.0	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 200 MHz) (Figure 1) (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 250 MHz) (Figure 6)	G_{pe}	 — 7.0	 11.4 7.6	 — —	dB
Intermodulation Distortion (I_C = 50 mAdc, V_{CE} = 15 Vdc, V_{out} = +50 dBmV)	IM	—	—	−50	dB
Cross Modulation Distortion (I_C = 50 mAdc, V_{CE} = 15 Vdc, V_{out} = +40 dBmV) (I_C = 50 mAdc, V_{CE} = 15 Vdc, V_{out} = +50 dBmV)	XM	 — —	 −67 −45	 — −42	dB

FIGURE 1 — NARROW-BAND TEST CIRCUIT

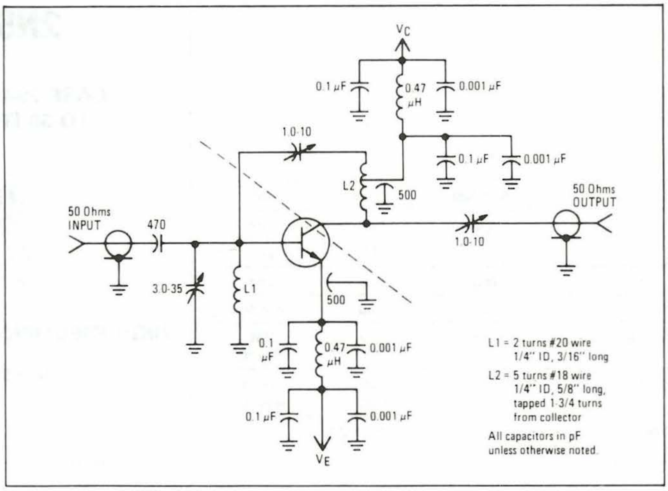


FIGURE 2 — CURRENT-GAIN — BANDWIDTH PRODUCT

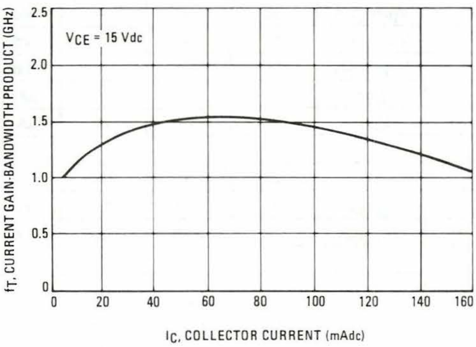


FIGURE 3 — COLLECTOR-BASE TIME CONSTANT

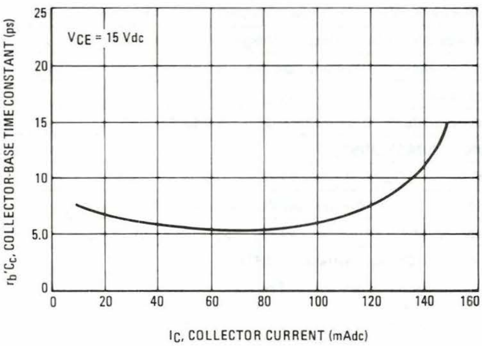


FIGURE 4 — SATURATION VOLTAGES

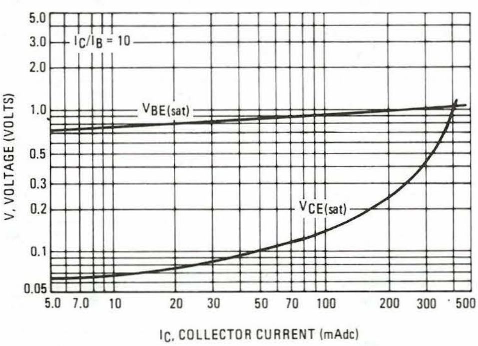


FIGURE 5 — CAPACITANCES versus REVERSE VOLTAGE

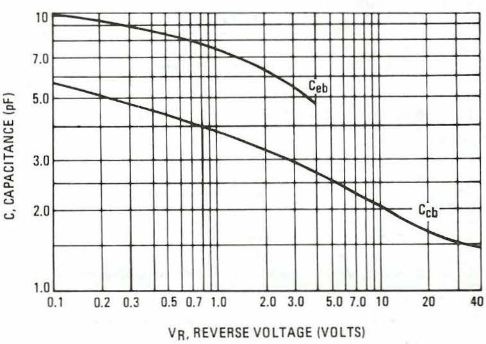
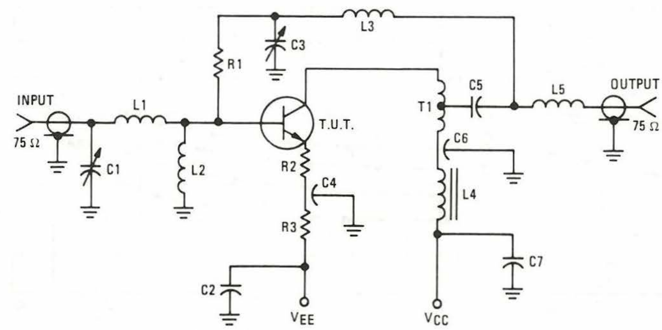


FIGURE 6 – BROADBAND TEST CIRCUIT



C1	1.0-10 pF	JOHANSON 2951 OR EQUIVALENT
C2, C7	0.01 μF	
C3	0.5-6.0 pF	JOHANSON 4642 OR EQUIVALENT
C4, C6	1500 pF	
C5	470 pF	
L1	2 TURNS AWG #26, 5/32" I.D.	
L2	1 μH MOLDED CHOKE	
L3	5 TURNS AWG #26, 3/32" I.D.	
L4	FERRITE CHOKE, 3 TURNS #30 ON STACKPOLE 57-0156 BEAD	
L5	2 TURNS AWG #26, 3/32" I.D.	
T1	AWG #30 TRIFILAR WOUND 1-9-9 ON STACKPOLE 57-0985, #11 TOROID	
R1	270 OHMS	
R2	18 OHMS	
R3	150 OHMS	

GARLOCK TEFLON SOCKET

FIGURE 7 – CROSS-MODULATION DISTORTION versus COLLECTOR CURRENT

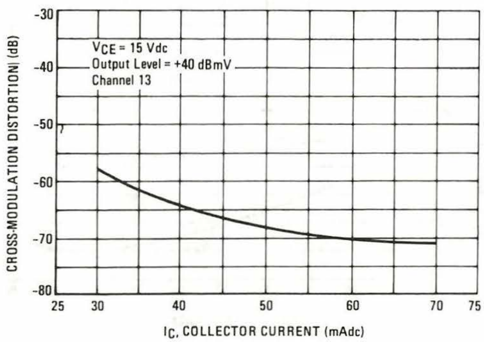


FIGURE 8 – CROSS-MODULATION DISTORTION versus OUTPUT LEVEL

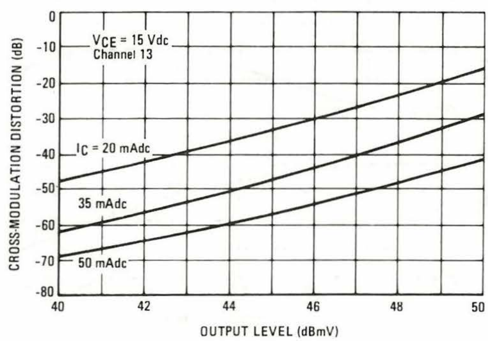


FIGURE 9 – NARROWBAND NOISE FIGURE versus COLLECTOR CURRENT

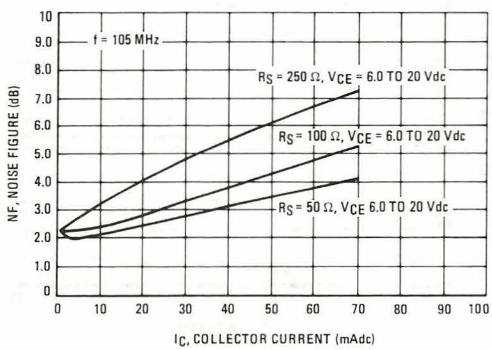


FIGURE 10 – NARROWBAND NOISE FIGURE versus COLLECTOR CURRENT

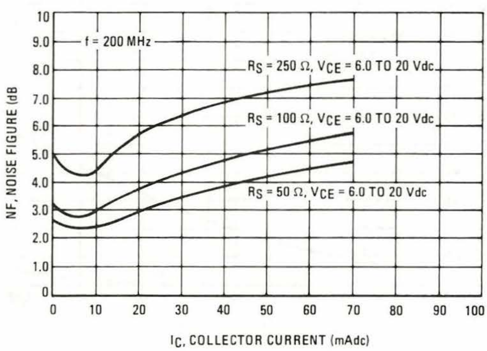


FIGURE 11 — BROADBAND NOISE FIGURE versus COLLECTOR CURRENT

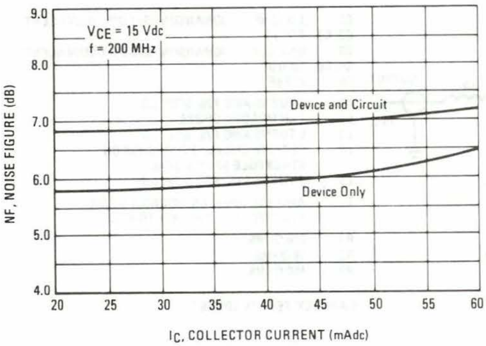


FIGURE 12 — NARROWBAND NOISE FIGURE versus FREQUENCY

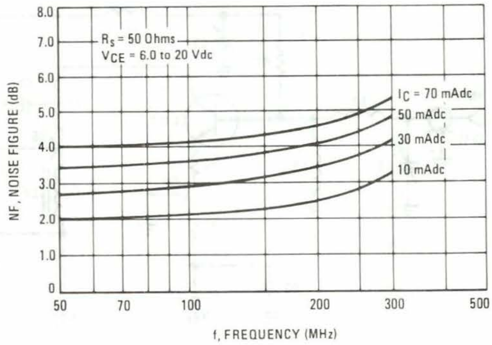


FIGURE 13 — INPUT ADMITTANCE versus FREQUENCY

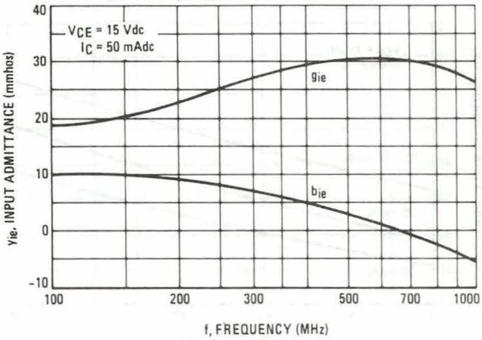


FIGURE 14 — INPUT ADMITTANCE versus COLLECTOR CURRENT

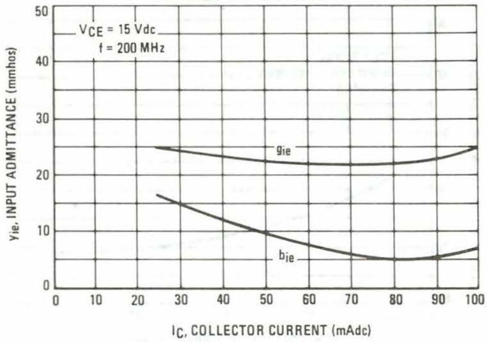


FIGURE 15 — REVERSE TRANSFER ADMITTANCE versus FREQUENCY

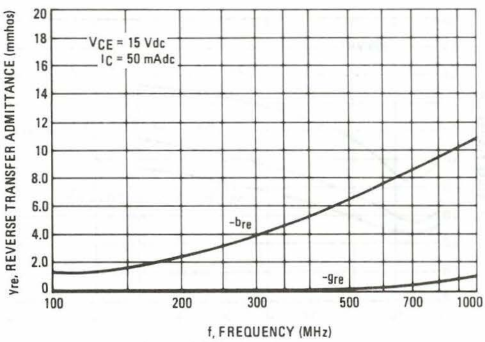
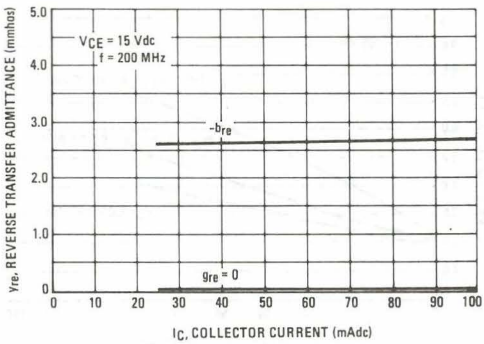


FIGURE 16 — REVERSE TRANSFER ADMITTANCE versus COLLECTOR CURRENT



7

FIGURE 17 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

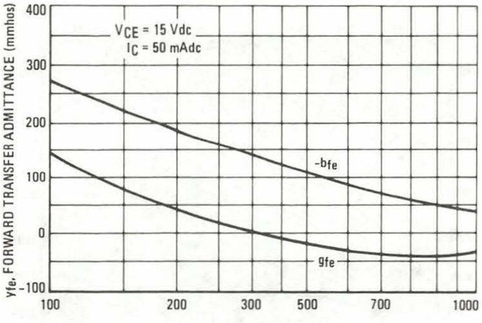


FIGURE 18 – FORWARD TRANSFER ADMITTANCE versus COLLECTOR CURRENT

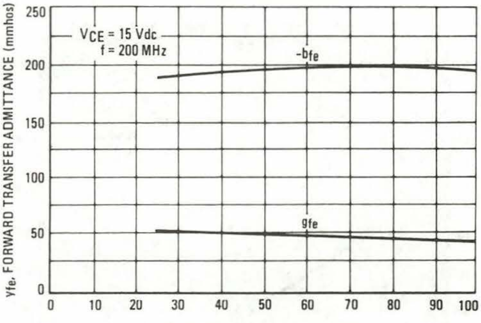


FIGURE 19 – OUTPUT ADMITTANCE versus FREQUENCY

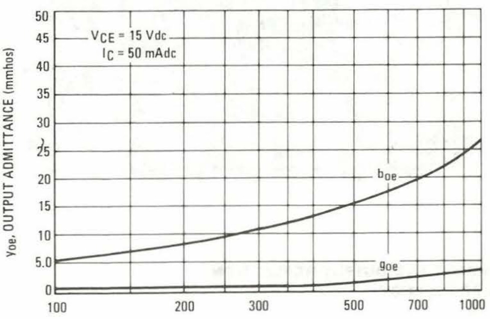


FIGURE 20 – OUTPUT ADMITTANCE versus COLLECTOR CURRENT

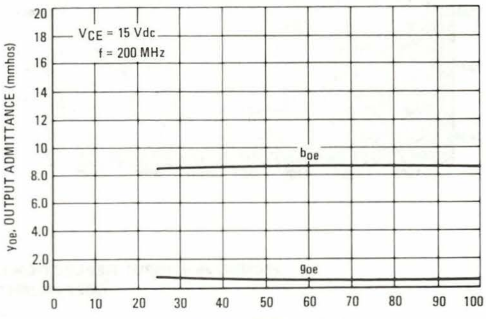


FIGURE 21 – INPUT REFLECTION COEFFICIENT versus FREQUENCY

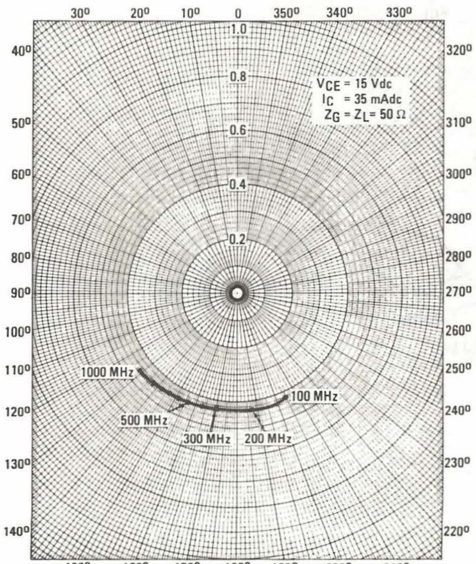


FIGURE 22 – OUTPUT REFLECTION COEFFICIENT versus FREQUENCY

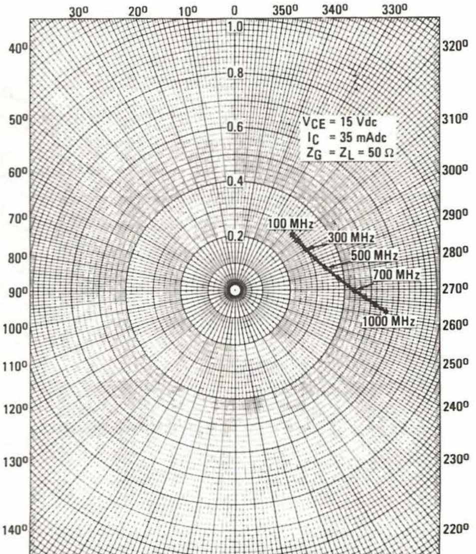


FIGURE 23 – REVERSE TRANSMISSION COEFFICIENT versus FREQUENCY

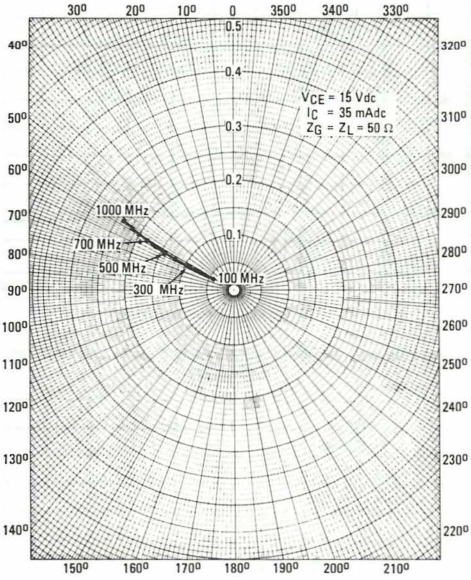
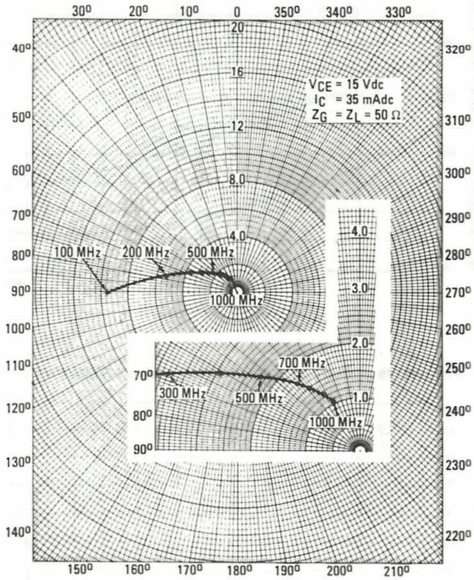
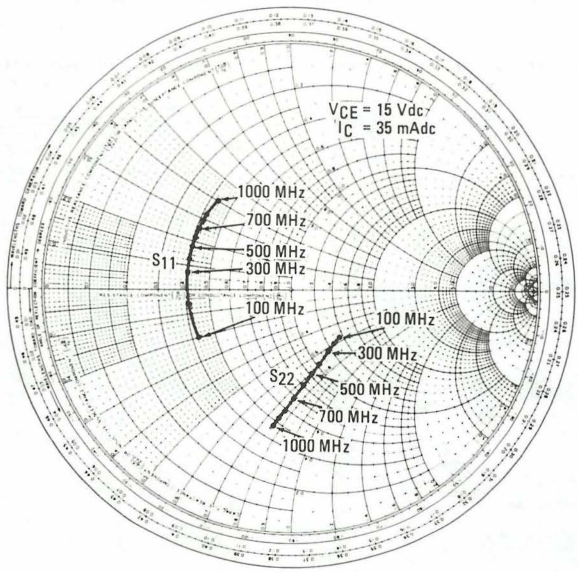


FIGURE 24 – FORWARD TRANSMISSION COEFFICIENT versus FREQUENCY



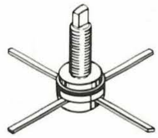
7

FIGURE 25 – INPUT REFLECTION COEFFICIENT AND OUTPUT REFLECTION COEFFICIENT versus FREQUENCY



2N5947

CASE 244A-01, STYLE 1
TO-117 (TO-232AA)



HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

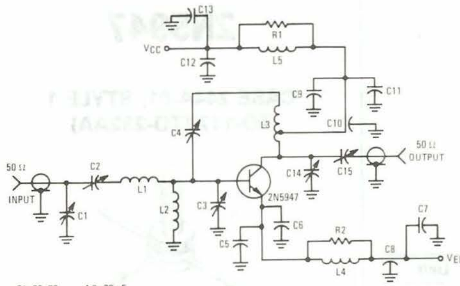
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	400	mAdc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 20$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 28$ Vdc, $I_B = 0$)	I_{CEO}	—	—	100	μAdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)	I_{CBO}	—	—	10	μAdc
Emitter Cutoff Current ($V_{BE} = 3.5$ Vdc, $I_C = 0$)	I_{EBO}	—	—	100	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 75$ mAdc, $V_{CE} = 20$ Vdc)	h_{FE}	25	—	250	—
Collector-Emitter Saturation Voltage ($I_C = 200$ mAdc, $I_B = 20$ mAdc)	$V_{CE(sat)}$	—	0.2	0.35	Vdc
Base-Emitter Saturation Voltage ($I_C = 200$ mAdc, $I_B = 20$ mAdc)	$V_{BE(sat)}$	—	1.0	1.5	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 75$ mAdc, $V_{CE} = 20$ Vdc, f = 200 MHz)	f_T	1100	1500	—	MHz
Collector-Base Capacitance ($V_{CB} = 30$ Vdc, $I_E = 0$, f = 100 kHz)	C_{cb}	—	1.5	4.0	pF
Emitter-Base Capacitance ($V_{EB} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)	C_{eb}	—	8.2	12	pF
Small Signal Current Gain ($I_C = 75$ mAdc, $V_{CE} = 20$ Vdc, f = 1.0 kHz)	h_{fe}	25	—	300	—
Collector Base Time Constant ($I_E = 75$ mAdc, $V_{CB} = 20$ Vdc, f = 31.8 MHz)	$r_b'C_c$	2.0	—	20	ps
Noise Figure ($I_C = 50$ mAdc, $V_{CE} = 20$ Vdc, f = 200 MHz) (Figure 1) ($I_C = 50$ mAdc, $V_{CE} = 20$ Vdc, f = 200 MHz)(1) (Figure 2) ($I_C = 75$ mAdc, $V_{CE} = 20$ Vdc, f = 200 MHz)(1) (Figure 2)	NF	 — — —	 3.8 7.2 7.8	 — 8.5 —	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (Figure 2) ($I_C = 75$ mAdc, $V_{CE} = 20$ Vdc, f = 250 MHz)	G_{pe}	10	11	—	dB
Intermodulation Distortion (Figure 2) ($I_C = 75$ mAdc, $V_{CE} = 20$ Vdc, $V_{out} = +50$ dBmV)	IM	—	−55	−50	dB
Cross Modulation Distortion (Figure 2) ($I_C = 75$ mAdc, $V_{CE} = 20$ Vdc, $V_{out} = +50$ dBmV)	XM	—	−60	−57	dB

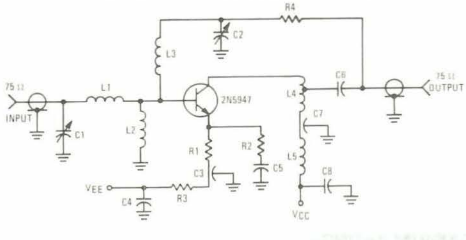
(1) Includes noise figure of post-amplifier and matching pad.

FIGURE 1 – NARROWBAND TEST CIRCUIT



C1, C2, C3	1.0–20 pF		
C4, C14, C15	1.0–10 pF	L2	1 1/2 Turns AWG #18, 1/4" I.D., 3/16" Long
C5, C8, C9	470 pF		
C6, C10, C11	0.001 μF	L3	9 3/4 Turns AWG #18, 3/16" I.D., 1" Long
C7, C13	0.01 μF		
C12	0.1 μF		Tapped 1 3/4 Turns from Collector End
L1	3 Turns AWG #18, 1/4" I.D., 5/16" Long	L4, L5	0.47 μH Molded Choke
		R1, R2	10 Ohms

FIGURE 2 – BROADBAND TEST CIRCUIT



C1, C2	0.5–6.0 pF	L4	#30 AWG Trifilar Wound 1:9:9 Stackpole 57-0985, #11 Toroid
C3, C7	1500 pF Underwood		
C4, C5, C8	0.01 μF	L5	Ferrite Choke, 3 Turns #30 on Stackpole 57-0156 Bead
C6	470 pF		
L1	3 Turns #20 AWG, 5/32" I.D.	R1	20 Ohms
L2	0.84 μH, Ohmite Z235	R2	68 Ohms
L3	5 Turns #26 AWG, 5/32" I.D.	R3	150 Ohms
		R4	360 Ohms

FIGURE 3 – CURRENT-GAIN–BANDWIDTH PRODUCT

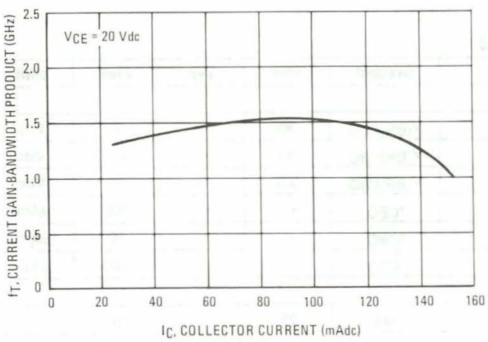


FIGURE 4 – CAPACITANCES

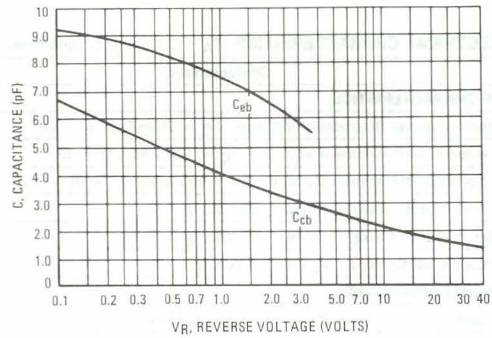


FIGURE 5 – COLLECTOR-EMITTER SATURATION VOLTAGE

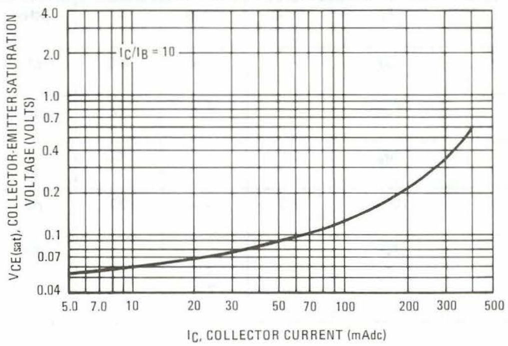
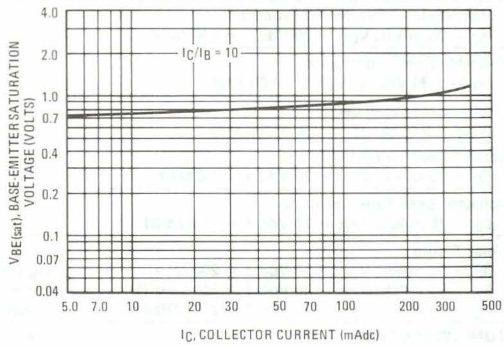


FIGURE 6 – BASE-EMITTER SATURATION VOLTAGE



7

FIGURE 7 — NARROWBAND NOISE FIGURE versus CURRENT

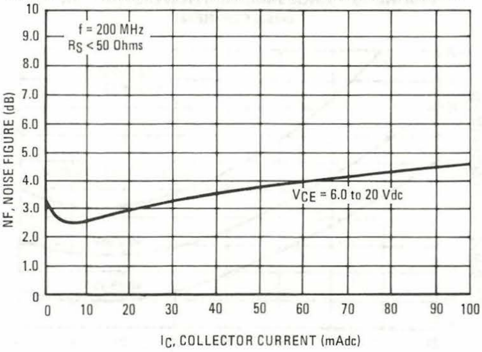


FIGURE 8 — BROADBAND NOISE FIGURE versus CURRENT

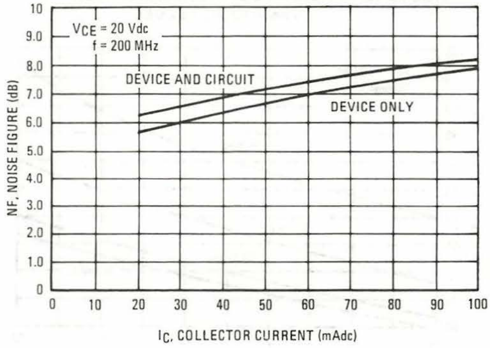
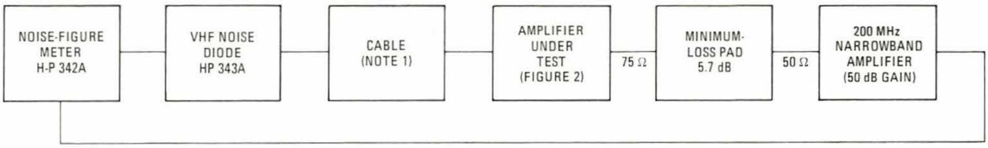


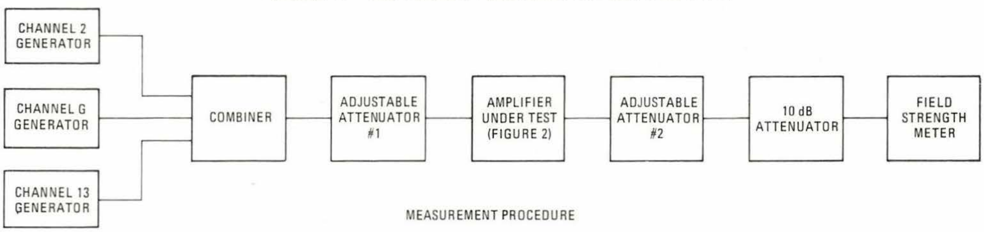
FIGURE 9 — NOISE FIGURE TEST SETUP



NOTE 1. RG-59 CABLE WITH ORIGINAL CENTER CONDUCTOR REPLACED WITH #30 WIRE. OVERALL LENGTH, INCLUDING BNC CONNECTORS, IS A QUARTER-WAVELENGTH AT 200 MHz (APPROX. 11 INCHES). USED TO MATCH IMPEDANCE OF NOISE DIODE TO AMPLIFIER UNDER TEST.

THE NOISE FIGURE OF THE POST-AMPLIFIERS AND MINIMUM LOSS PAD IS 8.4 dB.

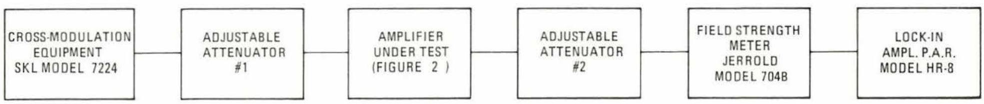
FIGURE 10 — INTERMODULATION DISTORTION TEST SETUP



MEASUREMENT PROCEDURE

1. ADJUST CHANNEL 2 GENERATOR FOR RATED OUTPUT FROM TEST AMPLIFIER (CHANNELS G & 13 OFF).
2. REPEAT FOR CHANNEL G (2 & 13 OFF) AND CHANNEL 13 (2 & G OFF). NOTE FOR REFERENCE THE FIELD STRENGTH METER READING FOR CHANNEL 13 (2 & G OFF).
3. TURN CHANNEL 13 OFF AND DRIVE THE TEST AMPLIFIER WITH CHANNELS 2 & G. MEASURE THE LEVEL OF INTERMODULATION DISTORTION AT CHANNEL 13 RELATIVE TO THE REFERENCE LEVEL IN STEP 2.

FIGURE 11 — CROSS MODULATION DISTORTION TEST SETUP



MEASUREMENT PROCEDURE

1. ADJUST THE CROSSMODULATION EQUIPMENT FOR +50 dBmV OUTPUT FROM EACH CHANNEL.
2. ADJUST ATTENUATOR #1 FOR THE DESIRED OUTPUT LEVEL FROM THE TEST AMPLIFIER. ADJUST ATTENUATOR #2 TO MAINTAIN THE FIELD STRENGTH METER INPUT AT +10 dBmV.
3. WITH THE FIELD STRENGTH METER SELECT CHANNEL 13. USING THE WAVE ANALYZER MEASURE THE LEVEL OF THE MODULATION ON CHANNEL 13 DUE TO CROSS-MODULATION OF CHANNELS 2-12.

7

FIGURE 12 – CROSS MODULATION DISTORTION versus OUTPUT LEVEL

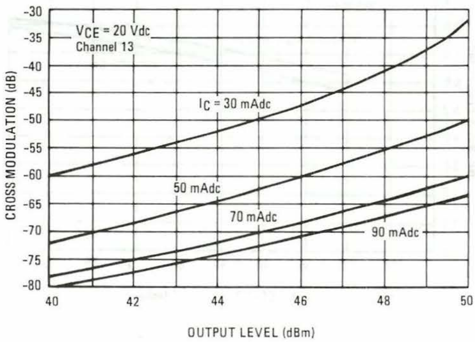
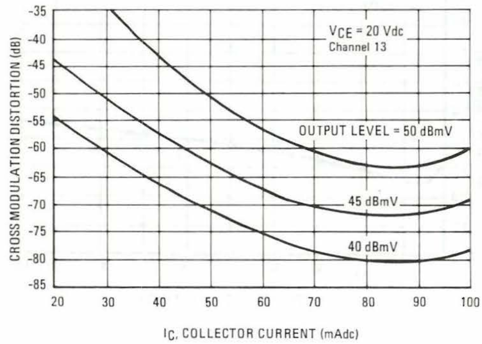


FIGURE 13 – CROSS MODULATION DISTORTION versus CURRENT



7

2N6255

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

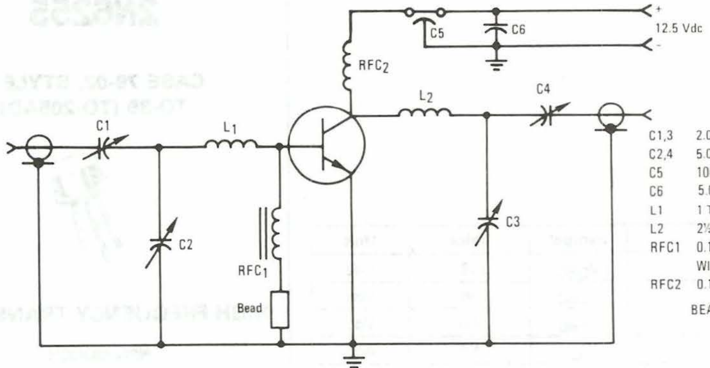
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.5	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	18	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 5.0$ mAdc, $V_{BE} = 0$)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 1.0$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	—	0.25	mAdc
Collector Cutoff Current ($V_{CE} = 15$ Vdc, $V_{BE} = 0$, $T_C = 55°C$)	I_{CES}	—	—	5.0	mAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 250$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	5.0	—	—	—
SMALL SIGNAL CHARACTERISTICS					
Output Capacitance ($V_{CB} = 12.5$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	15	20	pF
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain ($P_{out} = 3.0$ W, $V_{CC} = 12.5$ Vdc, f = 175 MHz)	G_{PE}	7.8	—	—	dB
Collector Efficiency ($P_{out} = 3.0$ W, $V_{CC} = 12.5$ Vdc, f = 175 MHz)	η	50	—	—	%

7

FIGURE 1 — 175 MHz CIRCUIT



C1,3	2.0-50 pF ARCO 461 ELMENCO
C2,4	5.0-80 pF ARCO 462 ELMENCO
C5	1000 pF FEED THRU
C6	5.0 μF
L1	1 TURN #18 AWG ¼" I.D.
L2	2½ TURNS #18 AWG ¼" I.D.
RFC1	0.15 μH MOLDED CHOKE WITH BEAD ON GROUND LEG
RFC2	0.15 μH MOLDED CHOKE

BEAD IS FERROXCUBE
56 570 65/3B

FIGURE 2 — OUTPUT POWER versus INPUT POWER

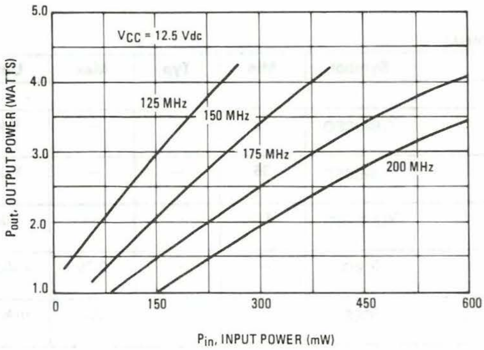
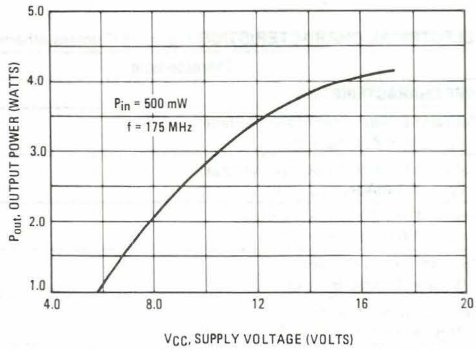


FIGURE 3 — OUTPUT POWER versus SUPPLY VOLTAGE



7

FIGURE 4 — COLLECTOR LOAD versus FREQUENCY

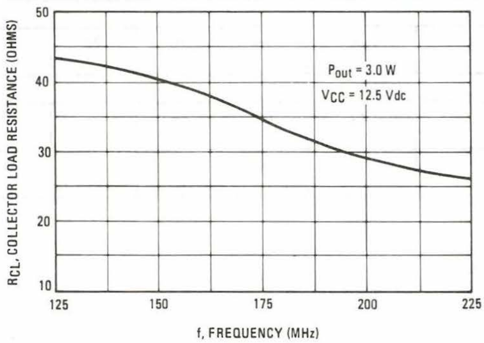


FIGURE 5 — PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

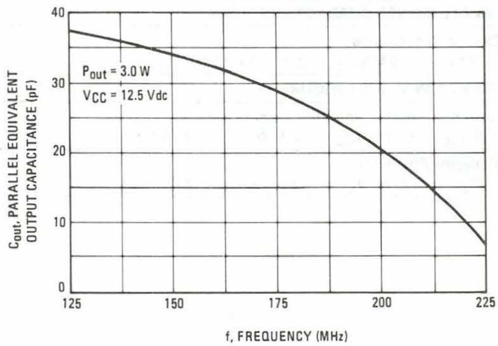


FIGURE 6 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

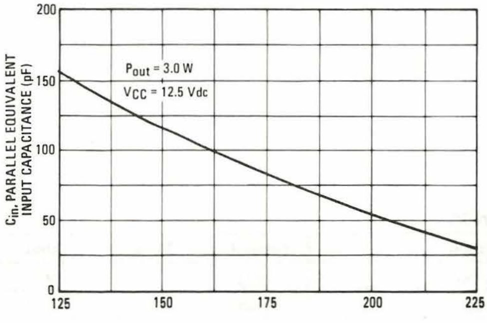
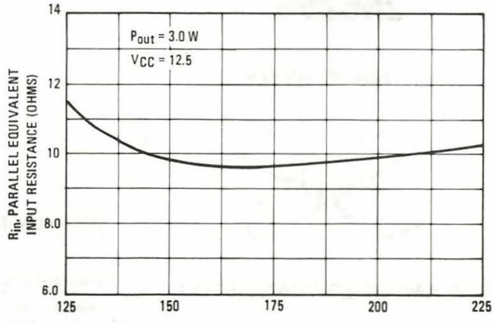
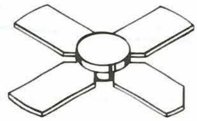


FIGURE 7 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY



2N6256

CASE 249-05, STYLE 1



UHF AMPLIFIER TRANSISTOR

NPN SILICON

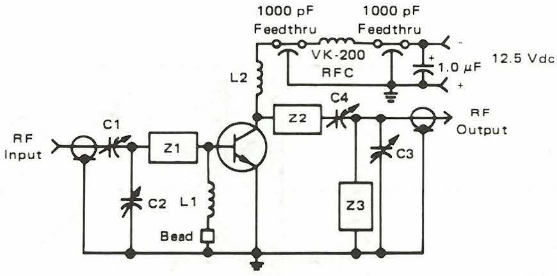
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	16	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	0.4	Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.0 11.4	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 5.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	16	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 5.0$ mAdc, $V_{BE} = 0$)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 1.0$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	—	0.5	mAdc
Collector Cutoff Current ($V_{CE} = 15$ Vdc, $V_{BE} = 0$, $T_A = 125°C$)	I_{CES}	—	—	5.0	mAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 50$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	20	80	200	—
SMALL SIGNAL CHARACTERISTICS					
Output Capacitance ($V_{CB} = 12.5$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	6.0	8.0	pF
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (Figures 1, 6) ($P_{out} = 0.5$ W, $V_{CC} = 12.5$ Vdc, f = 470 MHz)	G_{PE}	7.0	9.0	—	dB
Collector Efficiency (Figures 1, 6) ($P_{out} = 0.5$ W, $V_{CC} = 12.5$ Vdc, f = 470 MHz)	η	60	70	—	%

FIGURE 1 — 470 MHz TEST CIRCUIT SCHEMATIC



NOTE: Test Circuit Layout and Component Descriptions Shown in Figure 6.

Typical Output Power curves were measured in circuit shown in Figure 6.

FIGURE 2 — OUTPUT POWER versus FREQUENCY

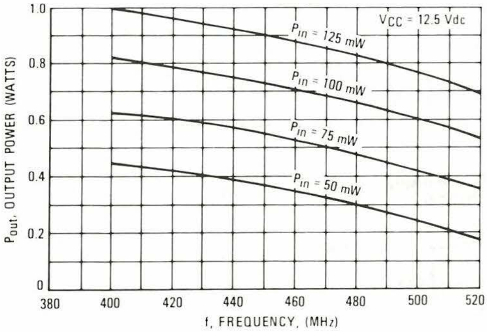


FIGURE 3 — OUTPUT POWER versus INPUT POWER

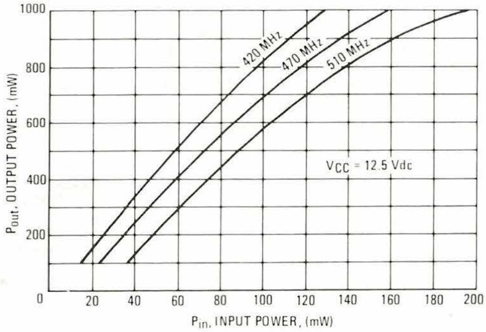


FIGURE 4 — OUTPUT POWER versus SUPPLY VOLTAGE

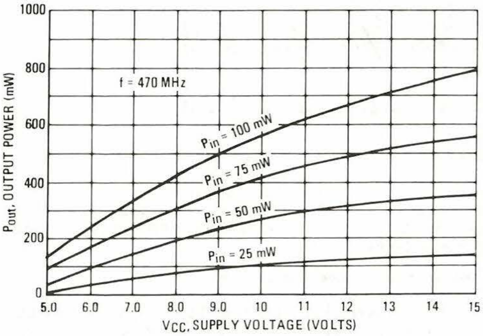


FIGURE 5 — SERIES EQUIVALENT INPUT and OUTPUT IMPEDANCE

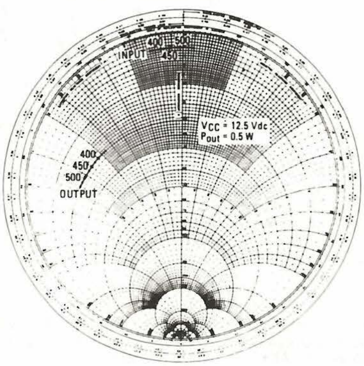
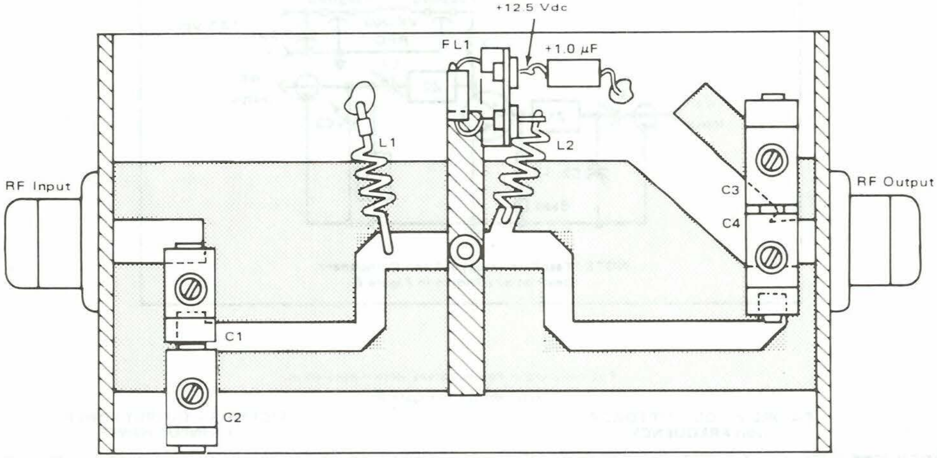


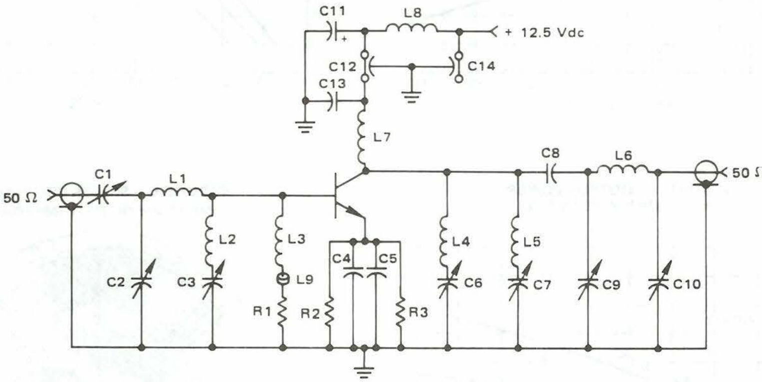
FIGURE 6 – 470 MHz TEST CIRCUIT LAYOUT
(See Figure 1 for Schematic Diagram)



C1, C2	1.0-25 pF ARCO 421 or Equivalent	FL1	DC Supply Filter	Connectors are Type "N"
C3, C4	1.0-25 pF ARCO 421 or Equivalent		2-1000 pF FT Capacitor	Board is Glass Teflon
L1, L2	7 Turns #22 AWG, 0.2" I.D.		1-1.0 μF, 35 V Capacitor	3" x 5" x 0.060"
	Ferrite Bead FERROXCUBE 56-590-65-3B		1-Choke FERROXCUBE	Mounting Plate is 3" x 5" x 0.75"
	as shown on L1		VK 200-20-4B	

7

FIGURE 7 – 150 MHz to 450 MHz TRIPLER USING 2N6256



C1,C2,C3,C9,C10	1-7 pF ARCO 400 or Equivalent	C13	0.1 μF Ceramic	L4	5 Turns 1/4" I.D.
C6,C7	1.5-20 pF ARCO 402 or Equivalent	R1	20 Ohm	L5	6 Turns 1/8" I.D.
C4,C5	470 pF ATC Type 100-B-420-m-ms	R2,R3	160 Ohm	L7	1 μH Molded Choke
C8	1000 pF UNDERWOOD Type J-101	L1	7 Turns 1/4" I.D.	L8	FERROXCUBE VK200-20/4B
C11	0.47 μF TANTALUM	L2	6-4 Turns 1/8" I.D.	L9	Ferrite Bead, FERROXCUBE 56-590-65/3B
C12,C14	470 pF Feedthru	L3	0.68 μH Molded Choke		

NOTE: All coils air core space wound with #20 AWG Wire, unless otherwise specified.

Figure 7 shows the 2N6256 in a 150 MHz to 450 MHz tripler circuit. This circuit will typically produce 85 mW at 450 MHz with 30 mW at 150 MHz input (4.5 dB gain). Collector efficiency is 25% and all unwanted harmonics are at least 30 dB down from the 450 MHz output level.

It is important that each emitter lead be bypassed separately with a good hi-quality capacitor. The emitter resistor is likewise split in two with one-half on each emitter lead.

The input network is a modified "TEE" consisting of C1, C2, and L1, which matches the 50 Ohm input to the transistor impedance at 150 mc; this is roughly 18-j20 Ohms. The combination of L2 and C3 form a 450 MHz idler to provide a base return for third harmonic current. L4, C6 and L5, C7 are 150 MHz and 300 MHz output idlers respectively. The output matching section is a pi network made up of L6, C9 and C10. All coils are air core space-wound (turns one wire diameter apart) with #20 AWG wire.

2N6304
2N6305

CASE 20-03, STYLE 10
TO-72 (TO-206AF)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

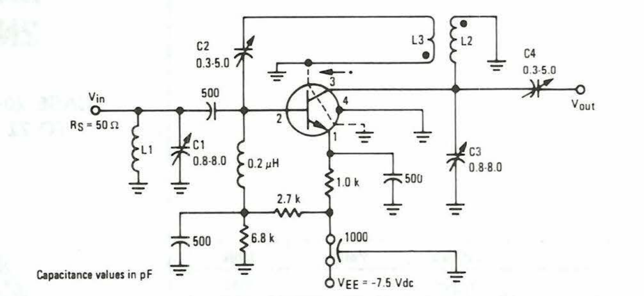
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	200 1.14	mW mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 5.0$ mAdc, $I_B = 0$)		$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)		$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)		$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 5.0$ Vdc, $I_E = 0$)		I_{CBO}	—	—	10	nAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 5.0$ Vdc)		h_{FE}	25	—	250	—
SMALL SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)	 2N6304 2N6305	f_T	 1400 1200	 — —	 — —	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{cb}	—	0.8	1.0	pF
Small Signal Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz)		h_{fe}	25	—	250	—
Collector Base Time Constant ($I_E = 2.0$ mAdc, $V_{CB} = 5.0$ Vdc, f = 31.8 MHz)	 2N6304 2N6305	$rb'C_c$	 2.0 2.0	 — —	 12 15	ps
Noise Figure ($I_C = 2.0$ mAdc, $V_{CE} = 5.0$ Vdc, $R_S = 50$ ohms, f = 450 MHz) (Figure 1)	 2N6304 2N6305	NF	 — —	 — —	 4.5 5.5	dB
FUNCTIONAL TEST						
Common-Emitter Amplifier Power Gain ($I_C = 2.0$ mAdc, $V_{CE} = 5.0$ Vdc, f = 450 MHz) (Figure 1)	 2N6304 2N6305	G_{pe}	 15 12	 — —	 — —	dB

FIGURE 1 – TEST CIRCUIT FOR NOISE FIGURE AND POWER GAIN



L1, L2 – Silver-plated brass rod, 1-1/2" long and 1/4" dia. Install at least 1/2" from nearest vertical chassis surface.
L3 – 1/2 turn #16 AWG wire, located 1/4" from and parallel to L2.
* – External interlead shield to isolate collector lead from emitter and base leads.

Neutralization Procedure:
(A) Connect 450-MHz signal generator (with R_S = 50 ohms) to input terminals of amplifier.
(B) Connect 50-ohm RF voltmeter across output terminals of amplifier.
(C) Apply V_{EE}, and with signal generator adjusted for 5 mV output from amplifier, tune C1, C3, and C4 for maximum output.
(D) Interchange connections to signal generator and RF voltmeter.
(E) With sufficient signal applied to output terminals of amplifier, adjust C2 for minimum indication at input.
(F) Repeat steps (A), (B), and (C) to determine if retuning is necessary.

FIGURE 2 – COLLECTOR-BASE CAPACITANCE versus COLLECTOR BASE VOLTAGE

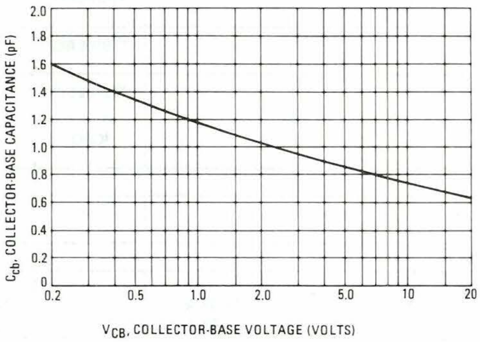


FIGURE 3 – CURRENT-GAIN-BANDWIDTH PRODUCT versus COLLECTOR CURRENT

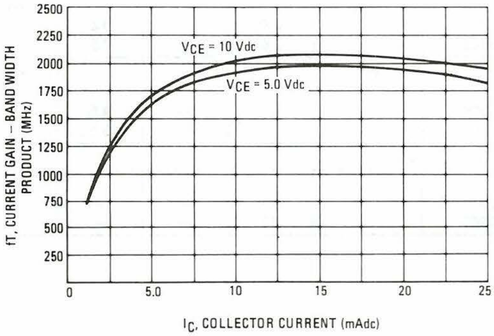


FIGURE 4 – COLLECTOR-BASE TIME CONSTANT versus EMITTER CURRENT

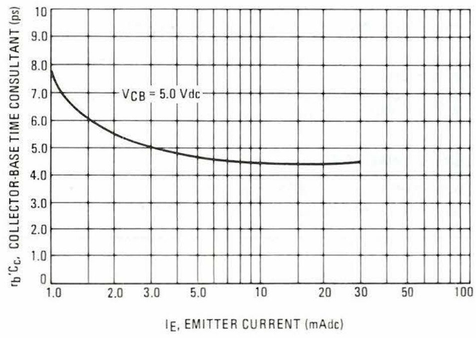


FIGURE 5 — REVERSE TRANSFER ADMITTANCE versus FREQUENCY

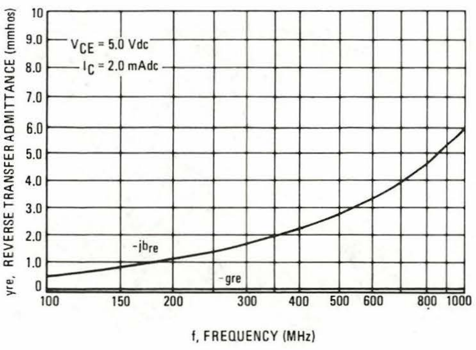


FIGURE 6 — INPUT ADMITTANCE versus FREQUENCY

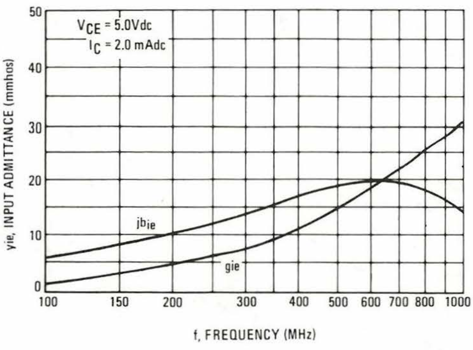


FIGURE 7 — OUTPUT ADMITTANCE versus FREQUENCY

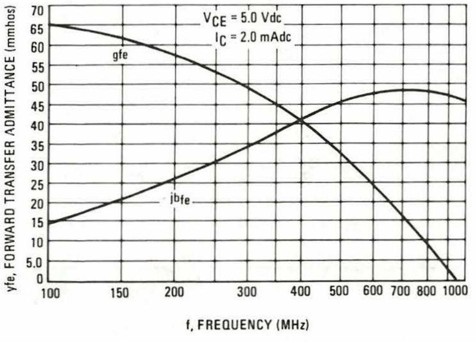
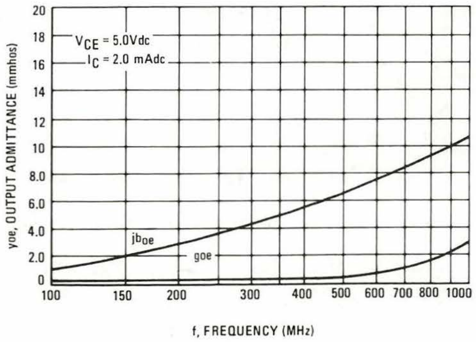


FIGURE 8 — FORWARD TRANSFER ADMITTANCE versus FREQUENCY



7

FIGURE 9 – S_{11}, INPUT REFLECTION COEFFICIENT

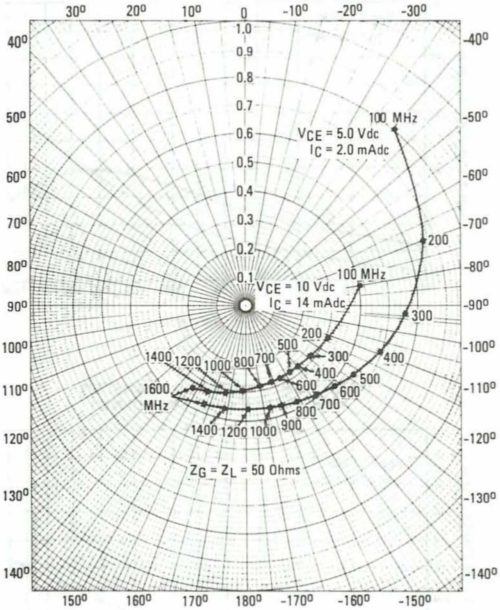


FIGURE 10 – S_{22}, OUTPUT REFLECTION COEFFICIENT

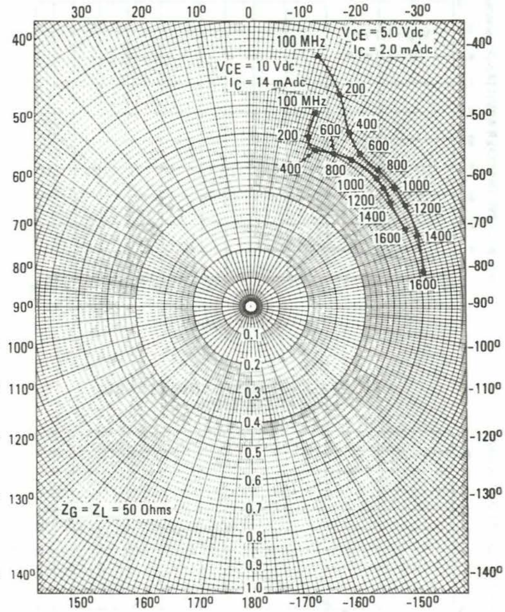


FIGURE 11 – S_{12}, REVERSE TRANSMISSION COEFFICIENT

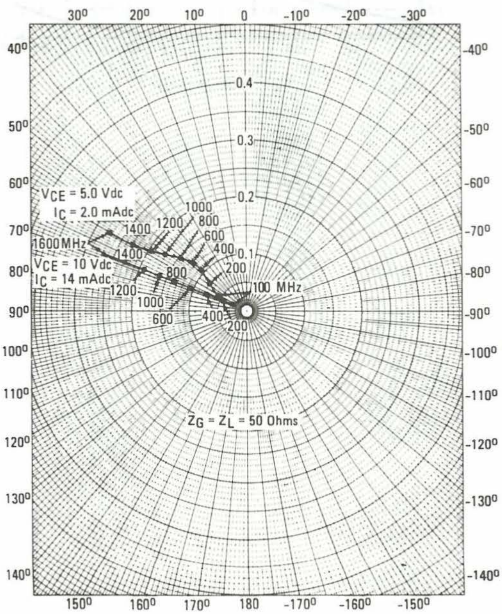


FIGURE 12 – S_{21}, FORWARD TRANSMISSION COEFFICIENT

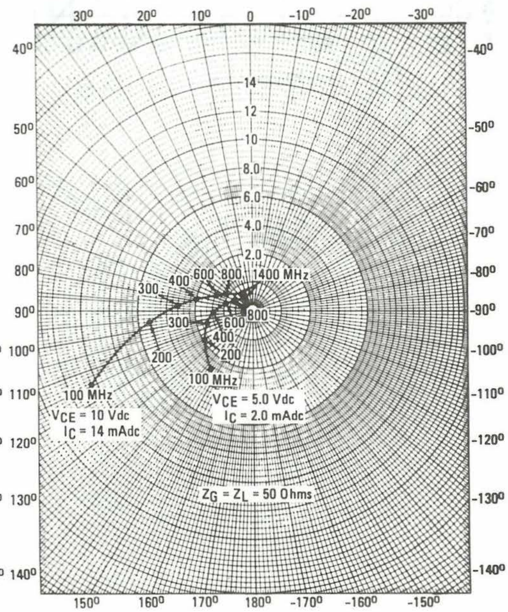
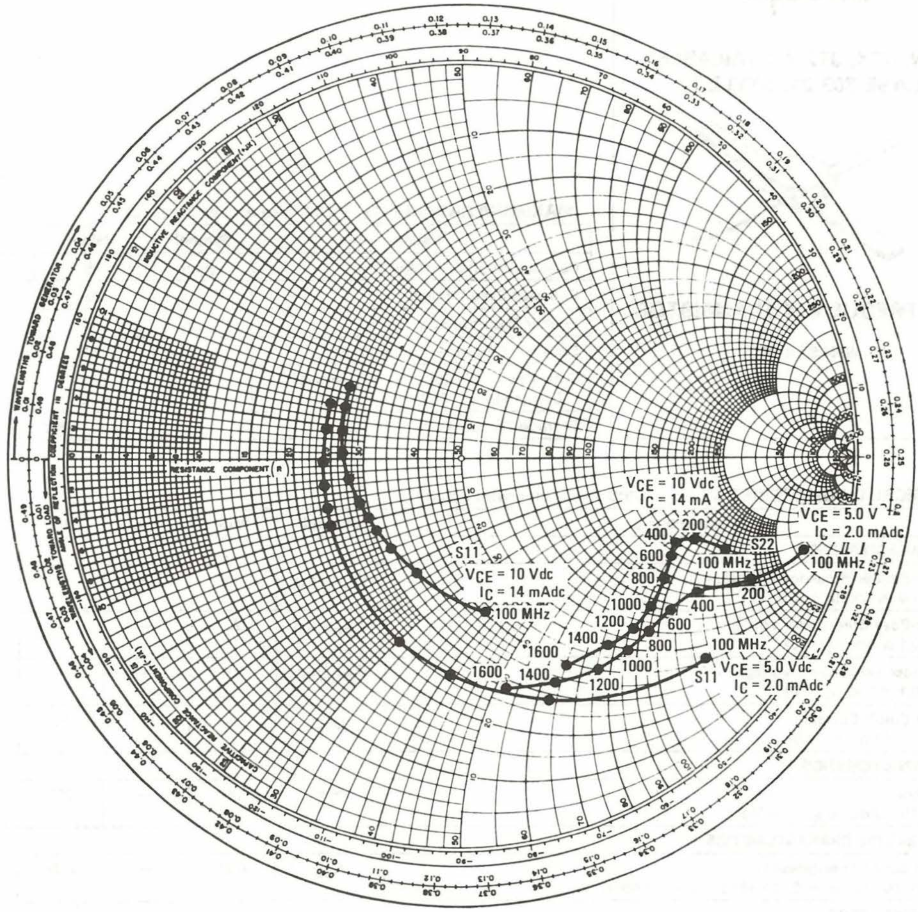


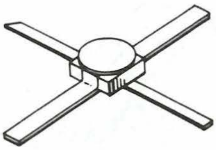
FIGURE 13 – S_{11}, INPUT REFLECTION COEFFICIENT AND S_{22}, OUTPUT REFLECTION COEFFICIENT



7

2N6603

JAN, JTX, JTXV AVAILABLE
CASE 303-01, STYLE 1



HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS (T_A = 25°C Free Air Temperature)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	30	mAdc
Total Device Dissipation @ T_C = 125°C Derate above 125°C	P_D	400 5.33	mW mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

7

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	25	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 15 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30	—	200	—
SMALL SIGNAL CHARACTERISTICS					
Collector-Base Capacitance(1) (V_{CB} = 10 Vdc, I_E = 0, 0.1 MHz $\leq f \leq$ 1.0 MHz)	C_{cb}	0.25	—	0.75	pF
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (Figure 1) (V_{CE} = 10 Vdc, I_C = 15 mA, f = 1.0 GHz)	G_{pe}	15	—	21	dB
Spot Noise Figure (R_S = Optimum) (Figure 1) (V_{CE} = 10 Vdc, I_C = 5.0 mA, f = 1.0 GHz)	NF	1.0	—	2.5	dB
Power Gain at Optimum Noise Figure (Figure 1) (V_{CE} = 10 Vdc, I_C = 5.0 mA, f = 1.0 GHz)	G_{NF}	10	—	—	dB
TYPICAL 2 GHz PERFORMANCE					
Maximum Available Gain (Figure 1)(2) (V_{CE} = 10 Vdc, I_C = 15 mA, f = 2.0 GHz)	MAG	—	11	—	dB
Noise Figure (R_S = Optimum) (Figure 1) (V_{CE} = 10 Vdc, I_C = 5.0 mA, f = 2.0 GHz)	NF	—	2.9	—	dB

(1) C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter terminal shall be connected to the guard terminal of the bridge.

(2) MAG is calculated from the S-Parameters using the equation MAG = $\frac{|S_{21}|^2}{(1 - |S_{11}|^2)(1 - |S_{22}|^2)}$

FIGURE 1 — BLOCK DIAGRAM FOR POWER GAIN AND NOISE FIGURE

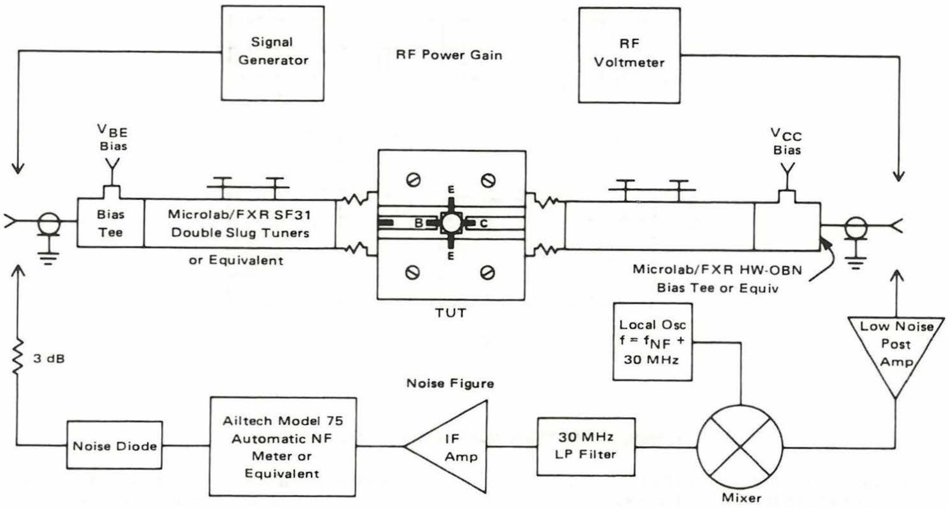


FIGURE 2 — POWER GAIN AND NOISE FIGURE versus FREQUENCY

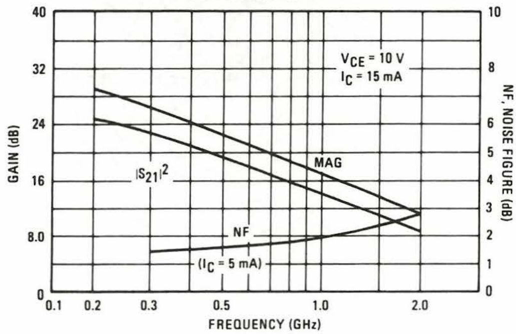


FIGURE 3 — OUTPUT CAPACITANCE versus VOLTAGE

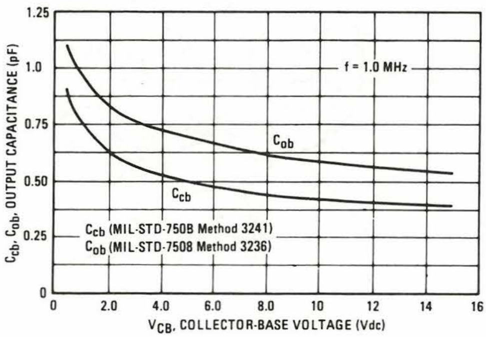


FIGURE 4 — CURRENT GAIN—BANDWIDTH PRODUCT versus COLLECTOR CURRENT

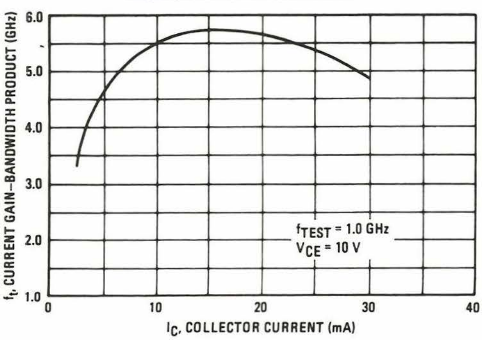


FIGURE 5 — POWER GAIN versus COLLECTOR CURRENT

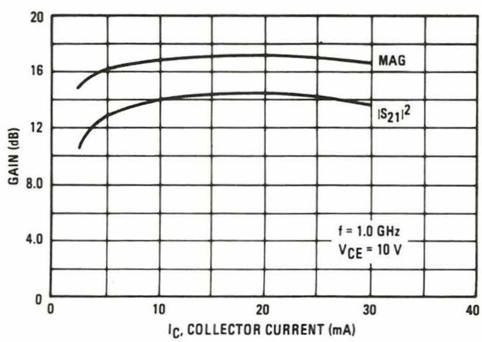
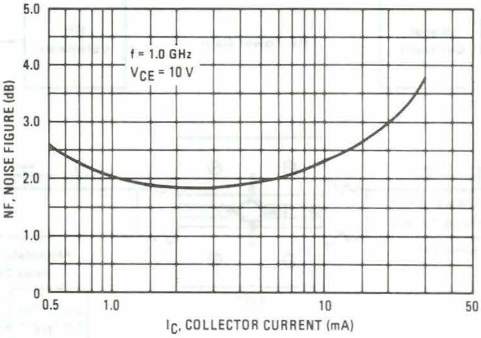


FIGURE 6 — NOISE FIGURE versus COLLECTOR CURRENT



COMMON EMITTER SCATTERING PARAMETERS

FIGURE 7 — INPUT AND OUTPUT REFLECTION COEFFICIENTS versus FREQUENCY

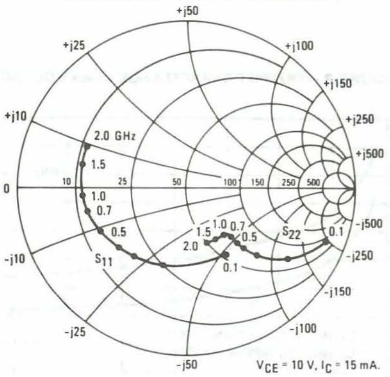
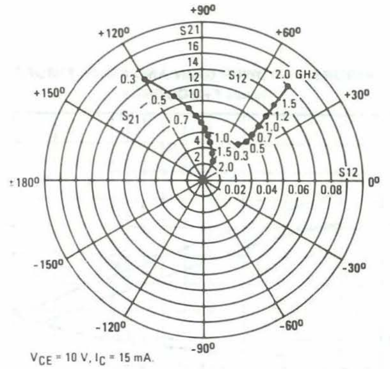


FIGURE 8 — FORWARD AND REVERSE TRANSMISSION COEFFICIENTS versus FREQUENCY



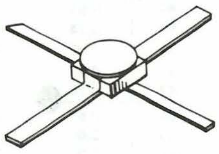
7

S – PARAMETERS

V_{CE} (Volts)	I_C (mA)	Frequency (MHz)	S11		S21		S12		S22	
			|S11|	∠φ	|S21|	∠φ	|S12|	∠φ	|S22|	∠φ
5.0	5	100	0.69	−30	12.16	160	0.026	72	0.95	−16
		200	0.65	−61	11.03	143	0.046	59	0.84	−31
		500	0.63	−122	7.05	111	0.074	36	0.56	−54
		1000	0.64	−158	4.13	88	0.087	28	0.39	−68
		2000	0.65	170	2.14	61	0.107	29	0.33	−91
	10	100	0.52	−50	18.74	154	0.022	69	0.91	−22
		200	0.54	−92	15.53	135	0.037	53	0.74	−40
		500	0.62	−146	8.49	104	0.052	38	0.43	−62
		1000	0.65	−172	4.66	84	0.065	37	0.29	−75
		2000	0.67	162	2.38	60	0.094	42	0.26	−97
	15	100	0.42	−70	22.72	150	0.019	66	0.87	−26
		200	0.51	−113	17.72	130	0.030	50	0.68	−44
		500	0.63	−157	8.96	100	0.042	41	0.38	−64
		1000	0.66	−178	4.80	82	0.056	44	0.26	−75
		2000	0.69	159	2.43	59	0.090	48	0.24	−97
	30	100	0.39	−116	24.57	142	0.014	62	0.80	−29
		200	0.55	−145	17.17	120	0.021	49	0.58	−42
		500	0.67	−171	7.96	95	0.030	49	0.34	−49
		1000	0.69	175	4.18	78	0.047	56	0.29	−56
		2000	0.71	157	2.13	55	0.084	58	0.29	−81
10	5	100	0.71	−27	12.01	161	0.021	73	0.96	−13
		200	0.67	−55	11.10	145	0.039	60	0.87	−25
		500	0.63	−115	7.44	114	0.064	39	0.62	−44
		1000	0.64	−153	4.43	90	0.077	30	0.46	−55
		2000	0.64	172	2.27	62	0.094	31	0.39	−76
	10	100	0.55	−43	18.77	155	0.018	71	0.92	−18
		200	0.55	−83	16.00	137	0.031	54	0.78	−32
		500	0.60	−140	9.06	106	0.046	39	0.49	−48
		1000	0.63	−168	5.02	85	0.058	39	0.36	−56
		2000	0.65	164	2.55	60	0.084	43	0.33	−76
	15	100	0.46	−60	23.14	152	0.016	68	0.90	−21
		200	0.51	−103	18.39	131	0.027	52	0.72	−36
		500	0.61	−152	9.67	102	0.037	42	0.43	−49
		1000	0.64	−175	5.21	83	0.049	45	0.33	−54
		2000	0.66	161	2.61	59	0.079	51	0.31	−74
	30	100	0.39	−98	27.29	144	0.013	63	0.83	−24
		200	0.53	−135	19.38	122	0.019	50	0.63	−35
		500	0.64	−167	9.11	96	0.027	48	0.41	−39
		1000	0.66	177	4.77	79	0.042	55	0.36	−45
		2000	0.69	157	2.41	56	0.074	58	0.35	−67

2N6604

JAN, JTX, JTXV AVAILABLE
CASE 303-01, STYLE 1



HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS (T_A = 25°C Free Air Temperature)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ T_C = 125°C Derate above 125°C	P_D	500 6.66	mW mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	25	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 30 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30	—	200	—
SMALL SIGNAL CHARACTERISTICS					
Collector-Base Capacitance(1) (V_{CB} = 10 Vdc, I_E = 0, 0.1 MHz ≤ f ≤ 1.0 MHz)	C_{cb}	0.30	—	0.80	pF
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (Figure 1) (V_{CE} = 10 Vdc, I_C = 30 mAdc, f = 1.0 GHz)	G_{pe}	15	—	21	dB
Spot Noise Figure (R_S = Optimum) (Figure 1) (V_{CE} = 10 Vdc, I_C = 5.0 mAdc, f = 1.0 GHz)	NF	1.5	—	3.0	dB
Power Gain at Optimum Noise Figure (Figure 1) (V_{CE} = 10 Vdc, I_C = 5.0 mAdc, f = 1.0 GHz)	G_{NF}	9.0	—	—	dB
TYPICAL 2 GHz PERFORMANCE					
Maximum Available Gain (Figure 1)(2) (V_{CE} = 10 Vdc, I_C = 30 mAdc, f = 2.0 GHz)	MAG	—	10	—	dB
Noise Figure (R_S = Optimum) (Figure 1) (V_{CE} = 10 Vdc, I_C = 5.0 mAdc, f = 2.0 GHz)	NF	—	4.3	—	dB

(1) C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter terminal shall be connected to the guard terminal of the bridge.

(2) MAG is calculated from the S-Parameters using the equation $MAG = \dfrac{|S_{21}|^2}{(1 - |S_{11}|^2)(1 - |S_{22}|^2)}$

FIGURE 1 — BLOCK DIAGRAM FOR POWER GAIN AND NOISE FIGURE

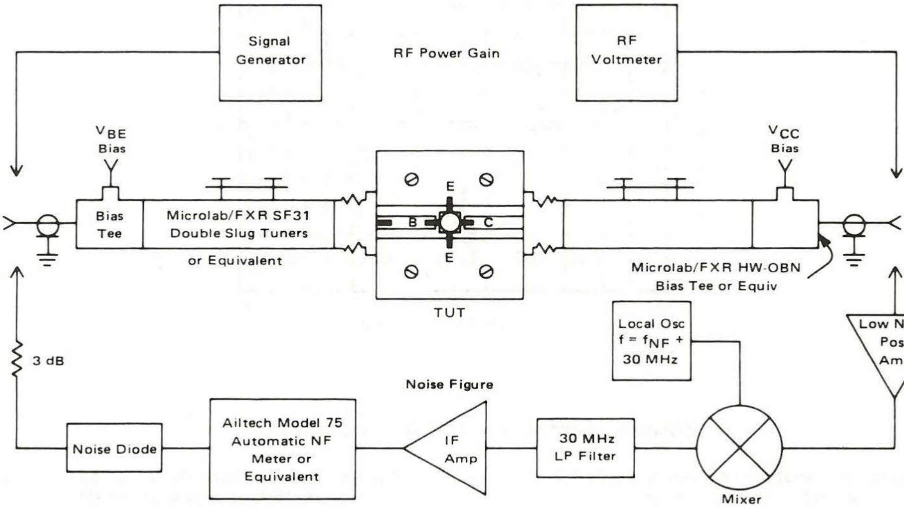


FIGURE 2 — POWER GAIN AND NOISE FIGURE versus FREQUENCY

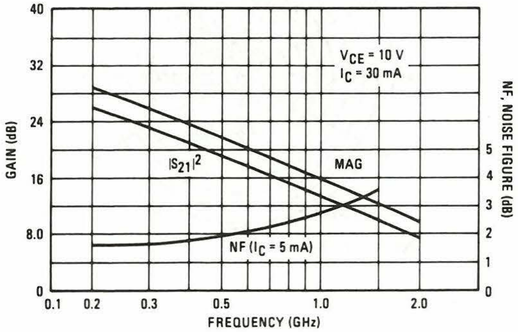


FIGURE 3 — OUTPUT CAPACITANCE versus VOLTAGE

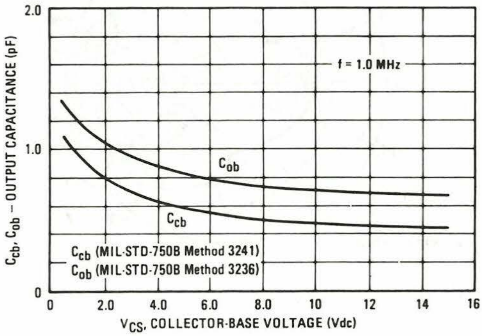


FIGURE 4 — CURRENT GAIN—BANDWIDTH PRODUCT versus COLLECTOR CURRENT

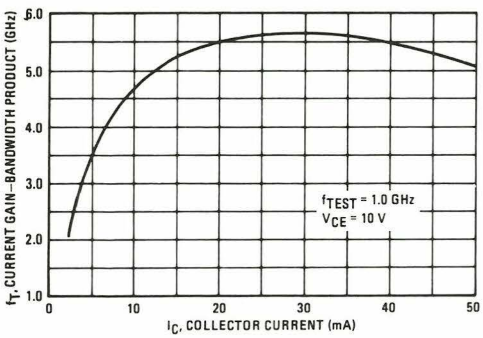


FIGURE 5 — POWER GAIN versus COLLECTOR CURRENT

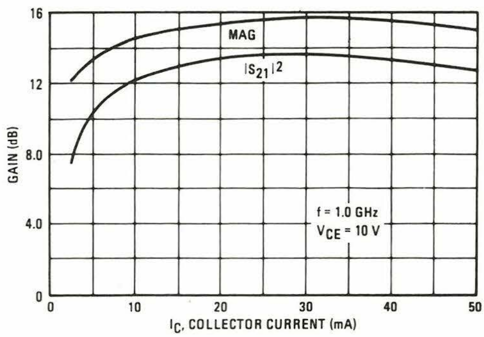
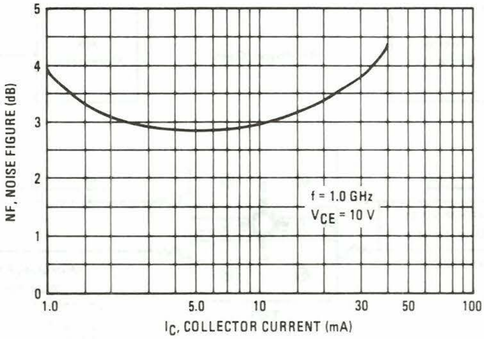


FIGURE 6 — NOISE FIGURE versus COLLECTOR CURRENT



COMMON EMITTER SCATTERING PARAMETERS

FIGURE 7 — INPUT AND OUTPUT REFLECTION COEFFICIENTS versus FREQUENCY

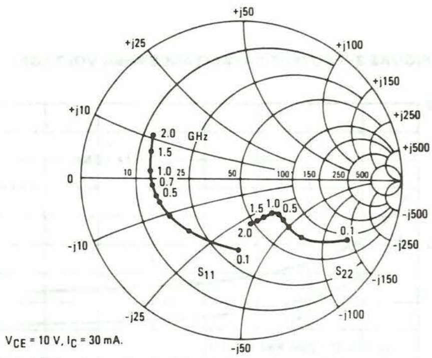
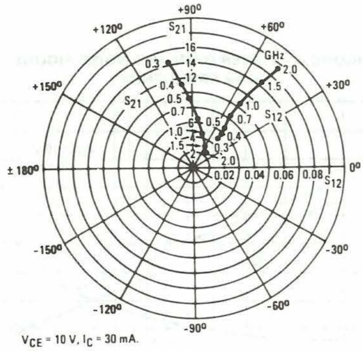


FIGURE 8 — FORWARD AND REVERSE TRANSMISSION COEFFICIENTS versus FREQUENCY



S – PARAMETERS

V_{CE} (Volts)	I_C (mA)	Frequency (MHz)	S11		S21		S12		S22	
			|S11|	∠φ	|S21|	∠φ	|S12|	∠φ	|S22|	∠φ
5.0	5	100	0.72	−40	12.37	153	0.028	67	0.91	−18
		200	0.65	−78	10.38	133	0.048	51	0.76	−32
		500	0.61	−137	5.75	100	0.067	34	0.50	−45
		1000	0.61	−168	3.13	78	0.082	31	0.41	−54
		2000	0.63	161	1.58	47	0.112	30	0.41	−80
	10	100	0.57	−60	19.54	146	0.024	63	0.85	−27
		200	0.55	−105	14.70	125	0.038	47	0.64	−43
		500	0.59	−155	7.12	95	0.051	39	0.37	−55
		1000	0.61	−178	3.77	76	0.069	40	0.29	−62
		2000	0.64	156	1.91	50	0.106	39	0.30	−86
	30	100	0.43	−111	30.58	135	0.016	57	0.72	−39
		200	0.53	−145	19.35	114	0.022	49	0.46	−57
		500	0.62	−173	8.42	91	0.035	51	0.24	−69
		1000	0.63	172	4.36	75	0.058	54	0.18	−76
		2000	0.67	151	2.19	52	0.099	49	0.21	−99
	50	100	0.46	−134	32.34	129	0.013	57	0.64	−42
		200	0.57	−158	19.19	110	0.018	51	0.40	−56
		500	0.64	−178	8.13	89	0.031	57	0.22	−62
		1000	0.65	170	4.17	74	0.053	58	0.19	−70
		2000	0.70	150	2.10	52	0.092	54	0.22	−97
10	5	100	0.74	−36	12.34	154	0.023	69	0.93	−15
		200	0.67	−71	10.56	135	0.040	54	0.81	−25
		500	0.59	−131	6.09	102	0.058	37	0.57	−36
		1000	0.58	−164	3.32	79	0.073	33	0.50	−44
		2000	0.60	164	1.67	48	0.098	32	0.49	−69
	10	100	0.60	−52	19.75	148	0.020	65	0.87	−21
		200	0.56	−95	15.30	127	0.032	49	0.69	−33
		500	0.56	−149	7.69	97	0.044	41	0.45	−41
		1000	0.58	−174	4.07	77	0.061	42	0.39	−47
		2000	0.61	159	2.03	50	0.095	40	0.39	−70
	30	100	0.44	−94	32.03	136	0.014	59	0.75	−31
		200	0.50	−135	20.76	115	0.021	49	0.52	−41
		500	0.57	−168	9.13	91	0.032	52	0.33	−43
		1000	0.59	175	4.71	75	0.052	54	0.29	−48
		2000	0.64	154	2.34	52	0.089	49	0.30	−72
	50	100	0.44	−117	33.56	129	0.012	59	0.68	−31
		200	0.52	−150	19.94	109	0.017	50	0.47	−36
		500	0.59	−174	8.52	89	0.028	56	0.34	−35
		1000	0.61	173	4.38	75	0.049	57	0.32	−43
		2000	0.66	152	2.21	51	0.083	52	0.34	−70

BFR90

CASE 317A-01, STYLE 2

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	30	mAdc
Total Device Dissipation @ $T_A = 60°C$ Derate above 60°C	P_D	180 2.0	mW mW/°C
Storage Temperature	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	500	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 10$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 14$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	25	—	250	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 14$ mAdc, $V_{CE} = 10$ Vdc, f = 0.5 GHz)	f_T	—	5.0	—	GHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	—	0.5	1.0	pF
FUNCTIONAL TEST					
Noise Figure ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, f = 0.5 GHz) ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 GHz)	NF	 — —	 2.4 3.0	 — —	dB
Power Gain at Optimum Noise Figure ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, f = 0.5 GHz) ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 GHz)	G_{NF}	 — —	 15 10	 — —	dB
Maximum Available Power(1) ($I_C = 14$ mAdc, $V_{CE} = 10$ Vdc, f = 0.5 GHz) ($I_C = 14$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 GHz)	G_{max}	 — —	 18 12	 — —	dB

(1) $G_{max} = \frac{|S_{21}|^2}{(1-|S_{11}|^2)(1-|S_{22}|^2)}$

7

FIGURE 1 – POWER DERATING

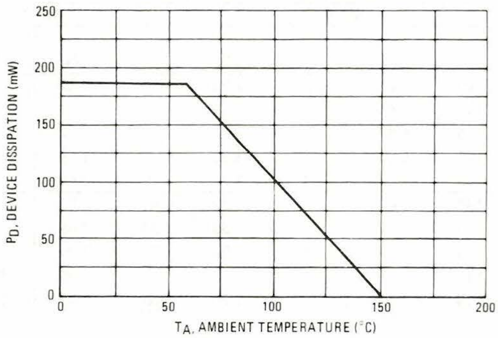


FIGURE 2 – POWER GAIN AND NOISE FIGURE versus FREQUENCY

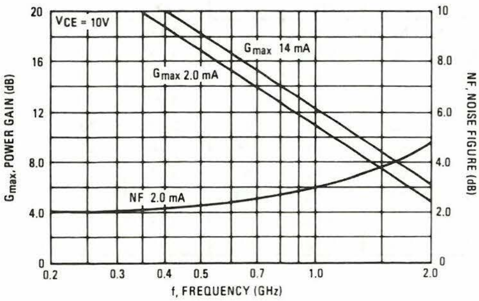


FIGURE 3 – POWER GAIN AND NOISE FIGURE versus COLLECTOR CURRENT

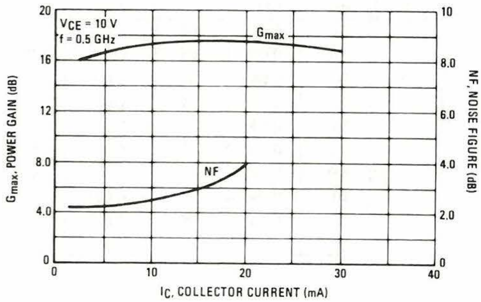


FIGURE 4 – S_{11} PARAMETERS

Frequency (MHz)		200		500		800		1000		1500	
V_{CE} (Volts)	I_C (mA)	S11	∠φ	S11	∠φ	S11	∠φ	S11	∠φ	S11	∠φ
5.0	2.0	0.77	-45	0.48	-90	0.33	-125	0.27	-160	0.28	170
	5.0	0.52	-60	0.25	-110	0.18	-150	0.18	170	0.21	145
	10	0.33	-75	0.15	-125	0.13	-175	0.15	150	0.20	130
	20	0.20	-95	0.12	-155	0.14	165	0.17	145	0.22	130
	30	0.17	-116	0.14	-170	0.17	160	0.21	145	0.26	130
10	2.0	0.79	-40	0.50	-80	0.33	-115	0.26	-150	0.25	175
	5.0	0.56	-55	0.27	-95	0.16	-135	0.13	-175	0.17	150
	10	0.39	-65	0.16	-105	0.10	-150	0.10	165	0.15	140
	20	0.25	-75	0.10	-120	0.09	-175	0.12	150	0.18	130
	30	0.25	-75	0.10	-120	0.09	-175	0.12	150	0.18	130

FIGURE 5 – S_{22} PARAMETERS

Frequency (MHz)		200		500		800		1000		1500	
V_{CE} (Volts)	I_C (mA)	S22	∠φ	S22	∠φ	S22	∠φ	S22	∠φ	S22	∠φ
5.0	2.0	0.89	-20	0.69	-30	0.61	-35	0.55	-35	0.52	-45
	5.0	0.75	-25	0.55	-30	0.50	-30	0.47	-30	0.43	-40
	10	0.64	-25	0.49	-25	0.45	-25	0.43	-30	0.40	-35
	20	0.57	-25	0.47	-20	0.44	-25	0.43	-25	0.40	-35
	30	0.55	-20	0.47	-20	0.46	-20	0.44	-25	0.42	-35
10	2.0	0.91	-15	0.74	-25	0.66	-30	0.62	-35	0.59	-40
	5.0	0.79	-20	0.61	-25	0.56	-25	0.54	-30	0.51	-35
	10	0.70	-20	0.56	-20	0.53	-25	0.51	-25	0.48	-35
	20	0.63	-20	0.54	-25	0.53	-20	0.51	-25	0.49	-35
	30	0.63	-15	0.56	-15	0.55	-20	0.54	-25	0.52	-35

FIGURE 6 – S_{21} PARAMETERS

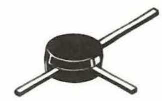
Frequency (MHz)		200		500		800		1000		1500	
V_{CE} (Volts)	I_C (mA)	S21	∠φ	S21	∠φ	S21	∠φ	S21	∠φ	S21	∠φ
5.0	2.0	5.76	140	3.81	105	2.73	90	2.20	75	1.70	60
	5.0	9.92	125	5.24	95	3.50	80	2.80	70	2.10	60
	10	12.33	115	5.82	90	3.79	75	2.90	65	2.20	55
	20	13.62	105	6.00	85	3.88	75	2.95	65	2.25	55
	30	13.41	105	5.80	80	3.74	75	2.85	65	2.15	55
10	2.0	5.77	145	3.88	110	2.80	90	2.25	75	1.75	60
	5.0	10.05	130	5.42	95	3.60	80	2.85	70	2.10	60
	10	12.56	115	6.00	90	3.90	80	3.05	70	2.25	55
	20	13.77	110	6.13	85	3.92	75	3.05	65	2.20	55
	30	13.23	105	5.79	85	3.70	75	2.85	65	2.15	55

FIGURE 7 – S_{12} PARAMETERS

Frequency (MHz)		200		500		800		1000		1500	
V_{CE} (Volts)	I_C (mA)	S12	∠φ	S12	∠φ	S12	∠φ	S12	∠φ	S12	∠φ
5.0	2.0	0.06	65	0.10	55	0.12	55	0.14	55	0.17	60
	5.0	0.05	65	0.08	65	0.12	65	0.15	65	0.19	65
	10	0.04	65	0.08	70	0.12	70	0.15	70	0.20	65
	20	0.04	75	0.08	75	0.12	75	0.15	70	0.20	70
	30	0.03	75	0.07	75	0.11	75	0.15	75	0.19	70
10	2.0	0.05	70	0.03	55	0.11	55	0.12	55	0.15	60
	5.0	0.04	65	0.07	65	0.10	65	0.13	65	0.17	70
	10	0.04	65	0.07	70	0.10	70	0.13	70	0.17	70
	20	0.03	70	0.07	75	0.10	75	0.13	75	0.17	70
	30	0.03	75	0.06	75	0.10	75	0.13	75	0.17	70

BFR91

CASE 317A-01, STYLE 2



HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	15	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	35	mAdc
Total Device Dissipation @ T_A = 60°C Derate above 60°C	P_D	180 2.0	mW mW/°C
Storage Temperature	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	500	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	12	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	15	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 5.0 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 30 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	25	—	250	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 30 mAdc, V_{CE} = 5.0 Vdc, f = 0.5 GHz)	f_T	—	5.0	—	GHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	0.7	1.0	pF
FUNCTIONAL TEST					
Noise Figure (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 0.5 GHz) (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 GHz)	NF	 — —	 1.9 2.5	 — —	dB
Power Gain at Optimum Noise Figure (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 0.5 GHz) (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 GHz)	G_{NF}	 — —	 11 8.0	 — —	dB
Maximum Available Power(1) (I_C = 30 mAdc, V_{CE} = 5.0 Vdc, f = 0.5 GHz) (I_C = 30 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 GHz)	G_{max}	 — —	 16 10	 — —	dB

(1) $G_{max} = \frac{|S_{21}|^2}{(1-|S_{11}|^2)(1-|S_{22}|^2)}$

7

FIGURE 1 – POWER DERATING

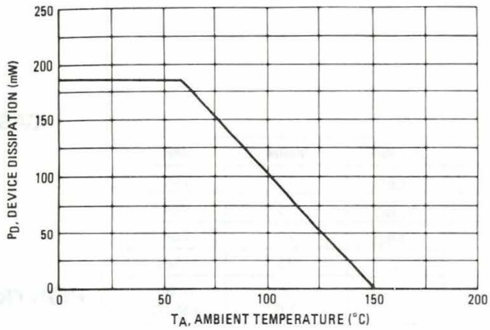


FIGURE 2 - POWER GAIN AND NOISE FIGURE versus FREQUENCY

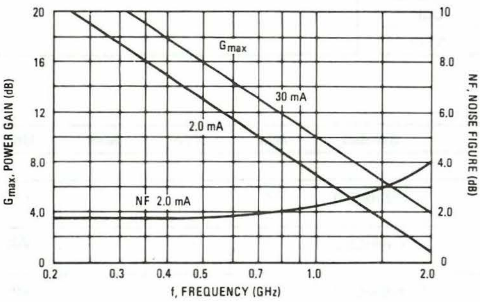
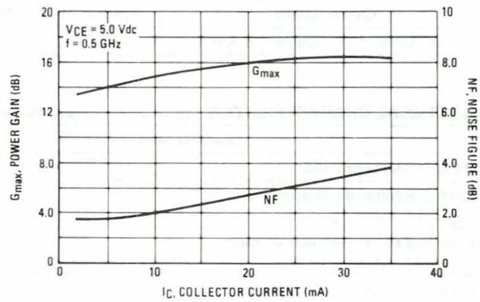


FIGURE 3 - POWER GAIN AND NOISE FIGURE versus COLLECTOR CURRENT



7

FIGURE 4 – S_{11} PARAMETERS

Frequency (MHz)		200		500		800		1000		1500	
V_{CE} (Volts)	I_C (mA)	S11	∠φ	S11	∠φ	S11	∠φ	S11	∠φ	S11	∠φ
5.0	2.0	0.72	-65	0.51	-125	0.46	-165	0.47	170	0.51	145
	5.0	0.49	-90	0.35	-150	0.34	175	0.36	155	0.41	135
	10	0.34	-110	0.28	-165	0.29	165	0.32	145	0.36	130
	20	0.26	-130	0.24	180	0.27	155	0.30	140	0.34	125
	30	0.24	-145	0.24	175	0.27	155	0.30	140	0.34	125
10	2.0	0.74	-60	0.51	-120	0.45	-160	0.45	170	0.49	150
	5.0	0.52	-80	0.33	-140	0.31	-175	0.32	160	0.37	145
	10	0.36	-95	0.24	-155	0.24	170	0.27	155	0.31	140
	20	0.25	-115	0.19	-170	0.21	160	0.24	145	0.29	130
	30	0.22	-120	0.19	-175	0.21	160	0.25	145	0.20	130

FIGURE 5 – S_{22} PARAMETERS

Frequency (MHz)		200		500		800		1000		1500	
V_{CE} (Volts)	I_C (mA)	S22	∠φ	S22	∠φ	S22	∠φ	S22	∠φ	S22	∠φ
5.0	2.0	0.83	-25	0.62	-35	0.55	-40	0.51	-45	0.49	-60
	5.0	0.66	-30	0.45	-35	0.40	-40	0.37	-40	0.34	-50
	10	0.52	-35	0.36	-35	0.32	-35	0.30	-35	0.27	-50
	20	0.42	-35	0.30	-30	0.27	-30	0.26	-30	0.22	-45
	30	0.38	-35	0.28	-25	0.26	-30	0.25	-30	0.21	-40
10	2.0	0.86	-20	0.67	-30	0.62	-35	0.58	-40	0.56	-50
	5.0	0.71	-25	0.53	-30	0.48	-30	0.45	-35	0.43	-45
	10	0.59	-30	0.45	-25	0.41	-30	0.40	-30	0.37	-40
	20	0.50	-25	0.40	-25	0.38	-25	0.37	-30	0.34	-40
	30	0.47	-25	0.40	-20	0.38	-25	0.37	-30	0.34	-35

FIGURE 6 – S_{21} PARAMETERS

Frequency (MHz)		200		500		800		1000		1500	
V_{CE} (Volts)	I_C (mA)	S21	∠φ	S21	∠φ	S21	∠φ	S21	∠φ	S21	∠φ
5.0	2.0	5.25	130	3.06	95	2.10	75	1.70	65	1.20	50
	5.0	8.72	120	4.34	90	2.84	75	2.30	65	1.60	50
	10	10.85	110	4.92	85	3.22	70	2.60	65	1.80	50
	20	12.13	105	5.34	80	3.44	70	2.75	60	1.90	50
	30	12.50	100	5.42	80	3.47		2.75	60	1.90	50
10	2.0	5.36	135	3.20	95	2.20	80	1.85	65	1.30	50
	5.0	9.05	120	4.55	90	3.00	75	2.45	65	1.65	50
	10	11.37	110	5.22	85	3.40	75	2.65	65	1.85	50
	20	12.83	105	5.64	80	3.63	70	2.75	60	2.00	50
	30	13.10	100	5.62	80	3.63	70	2.75	60	2.00	50

FIGURE 7 – S_{12} PARAMETERS

Frequency (MHz)		200		500		800		1000		1500	
V_{CE} (Volts)	I_C (mA)	S12	∠φ	S12	∠φ	S12	∠φ	S12	∠φ	S12	∠φ
5.0	2.0	0.08	55	0.11	45	0.12	50	0.14	55	0.17	65
	5.0	0.06	55	0.09	60	0.13	65	0.17	65	0.22	65
	10	0.05	60	0.09	65	0.14	70	0.19	65	0.24	65
	20	0.05	70	0.07	70	0.15	70	0.19	70	0.25	65
	30	0.04	75	0.10	75	0.15	70	0.19	70	0.25	65
10	2.0	0.06	60	0.09	45	0.10	50	0.12	60	0.15	70
	5.0	0.05	60	0.08	60	0.11	65	0.15	65	0.19	70
	10	0.05	65	0.08	65	0.12	70	0.16	70	0.21	70
	20	0.04	70	0.08	70	0.13	70	0.17	70	0.22	70
	30	0.04	70	0.08	75	0.13	70	0.17	70	0.22	70

BFR96

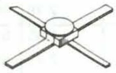
CASE 317A-01, STYLE 2

MRF961

CASE 317-01, STYLE 2

MRF962

CASE 303-01, STYLE 1



MRF965

CASE 26-03, STYLE 1
TO-46 (TO-206AB)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	BFR96 MRF961	MRF962 MRF965	Unit
Collector-Emitter Voltage	V_{CEO}	15	15	Vdc
Collector-Base Voltage	V_{CBO}	20	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	3.0	Vdc
Collector Current — Continuous	I_C	100	100	mAdc
Total Device Dissipation @ T_C = 100°C Derate above 100°C	P_D	0.5 5.0	0.75 7.5	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +150	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)		I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc)		h_{FE}	30	—	200	—
SMALL SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)		f_T	—	4.5	—	GHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, Emitter Guarded)	BFR96, MRF961, MRF962 MRF965	C_{cb}	— —	1.2 1.6	1.5 2.0	pF
FUNCTIONAL TEST						
Noise Figure (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)		NF	—	2.0	—	dB
Maximum Available Gain/Insertion Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)	BFR96, MRF965 MRF961 MRF962	MAG/$\|S_{21}\|^2$	−/12 −/13.5 −/15	14.5/13 17/15 20.5/16.5	— — —	dB

NOTE 1. MAG = $\dfrac{|S_{21}|^2}{(1-|S_{11}|^2)(1-|S_{22}|^2)}$

FIGURE 1 – MAXIMUM AVAILABLE GAIN versus FREQUENCY

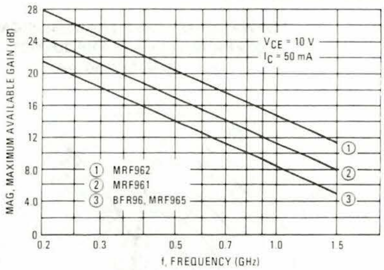


FIGURE 2 – $|S_{21}|^2$ versus FREQUENCY

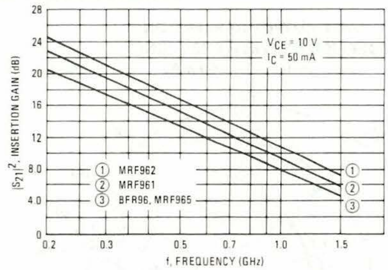


FIGURE 3 – MAXIMUM AVAILABLE GAIN versus COLLECTOR CURRENT

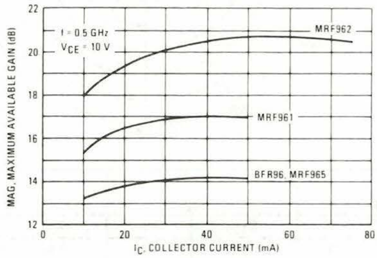


FIGURE 4 – GAIN-BANDWIDTH PRODUCT versus COLLECTOR CURRENT

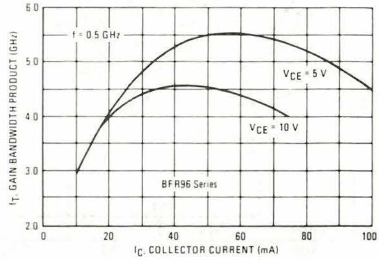


FIGURE 5 – NOISE FIGURE versus FREQUENCY

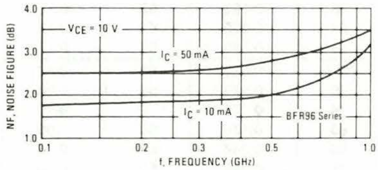


FIGURE 6 – NOISE FIGURE versus COLLECTOR CURRENT

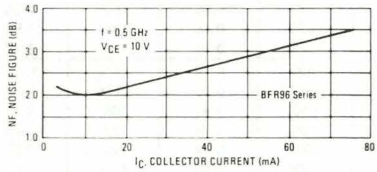


FIGURE 7 – COLLECTOR-BASE CAPACITANCE versus COLLECTOR-BASE VOLTAGE

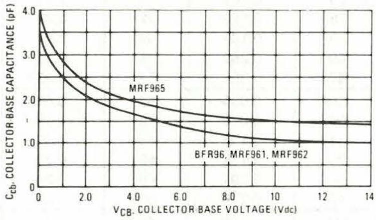


FIGURE 8 – OUTPUT POWER AND EFFICIENCY versus INPUT POWER (MRF965)

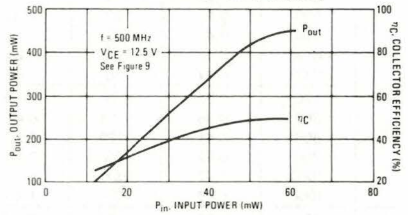
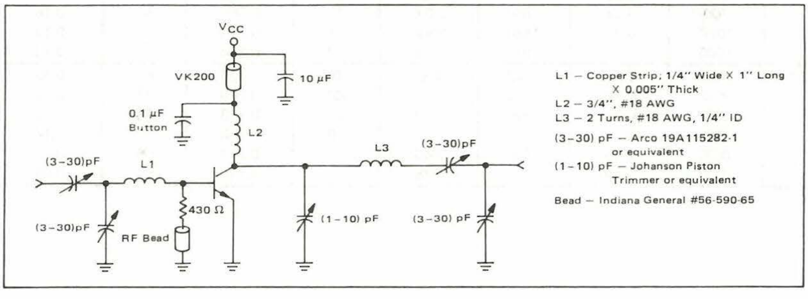


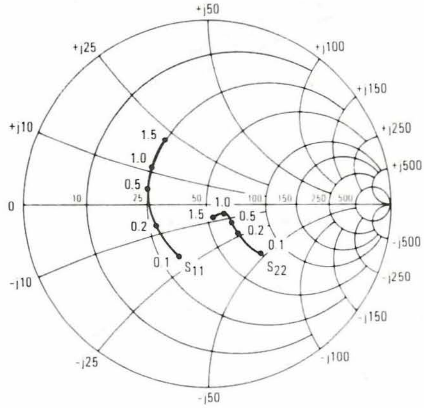
FIGURE 9 – MRF965 CLASS C AMPLIFIER @ 500 MHz, 400 mW



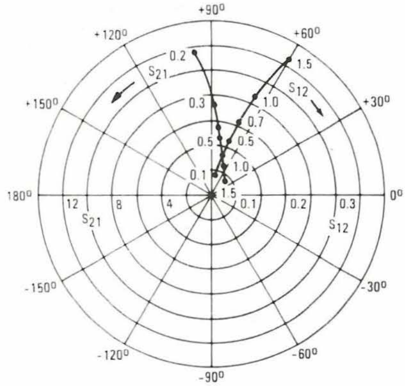
7

BFR96 COMMON-EMITTER S-PARAMETERS

INPUT/OUTPUT REFLECTION COEFFICIENTS versus FREQUENCY (V_{CE} = 10 V, I_C = 50 mA)



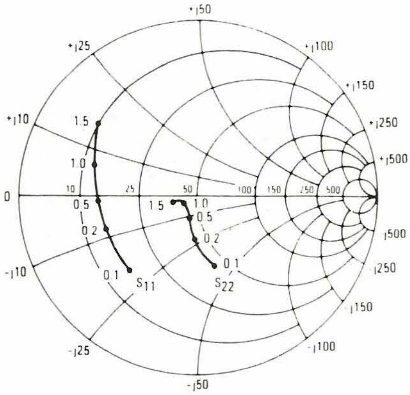
FORWARD/REVERSE TRANSMISSION COEFFICIENTS versus FREQUENCY (V_{CE} = 10 V, I_C = 50 mA)



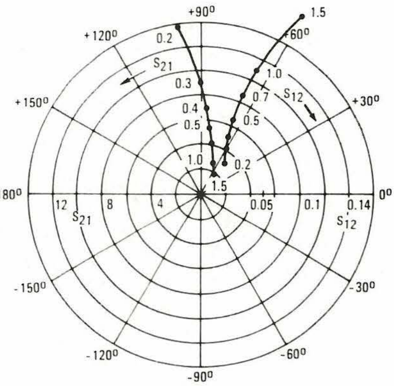
V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11}\rvert$	$\angle\phi$	$\lvert S_{21}\rvert$	$\angle\phi$	$\lvert S_{12}\rvert$	$\angle\phi$	$\lvert S_{22}\rvert$	$\angle\phi$
5.0	10	100	0.51	-95	15.04	121	0.047	54	0.58	-48
		300	0.43	-163	5.87	92	0.082	58	0.26	-63
		500	0.46	174	3.61	79	0.120	63	0.19	-63
		700	0.48	162	2.65	68	0.161	63	0.15	-64
		1000	0.48	146	1.92	57	0.220	63	0.12	-79
		1500	0.54	121	1.40	43	0.320	58	0.13	-118
	25	100	0.39	-122	19.41	112	0.037	60	0.42	-68
		300	0.39	-176	6.81	89	0.079	68	0.16	-94
		500	0.42	166	4.11	78	0.129	70	0.10	-103
		700	0.44	156	3.05	69	0.176	68	0.06	-119
		1000	0.44	142	2.20	59	0.244	64	0.06	-159
		1500	0.49	118	1.62	45	0.348	57	0.10	177
	50	100	0.35	-140	21.10	106	0.032	64	0.33	-81
		300	0.38	176	7.11	88	0.081	72	0.13	-116
		500	0.42	162	4.28	78	0.133	72	0.09	-136
		700	0.43	153	3.16	70	0.183	69	0.07	-163
		1000	0.42	140	2.28	60	0.252	65	0.08	165
		1500	0.47	116	1.66	47	0.357	57	0.12	155
10	10	100	0.53	-83	15.96	124	0.039	58	0.65	-36
		300	0.38	-154	6.44	94	0.070	59	0.35	-41
		500	0.41	-179	3.98	81	0.102	64	0.30	-39
		700	0.42	166	2.94	70	0.138	65	0.27	-39
		1000	0.42	151	2.12	60	0.191	66	0.24	-47
		1500	0.49	125	1.50	44	0.278	63	0.22	-72
	25	100	0.38	-104	20.85	115	0.032	60	0.48	-48
		300	0.32	-169	7.54	91	0.070	68	0.23	-48
		500	0.35	170	4.61	80	0.109	71	0.19	-43
		700	0.37	160	3.37	70	0.152	69	0.16	-39
		1000	0.37	146	2.43	61	0.210	67	0.13	-44
		1500	0.43	121	1.73	47	0.304	61	0.10	-74
	50	100	0.33	-119	22.59	109	0.029	63	0.39	-51
		300	0.30	-176	7.74	88	0.069	72	0.19	-47
		500	0.34	166	4.70	79	0.113	73	0.16	-40
		700	0.36	158	3.45	70	0.156	70	0.14	-35
		1000	0.36	144	2.46	61	0.217	66	0.11	-39
		1500	0.42	119	1.75	47	0.310	60	0.08	-72

MRF961 COMMON-EMITTER S-PARAMETERS

INPUT/OUTPUT REFLECTION COEFFICIENTS versus FREQUENCY (V_{CE} = 10 V, I_C = 50 mA)



FORWARD/REVERSE TRANSMISSION COEFFICIENTS versus FREQUENCY (V_{CE} = 10 V, I_C = 50 mA)

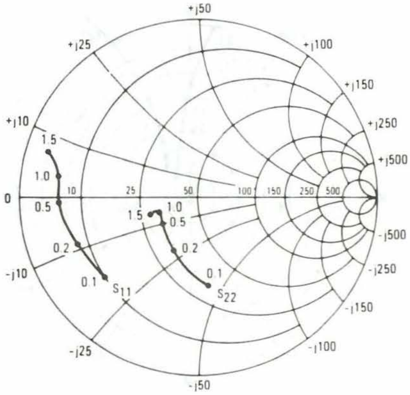


V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11} $\|S_{11}\|$	S_{11} $\angle\phi$	S_{21} $\|S_{21}\|$	S_{21} $\angle\phi$	S_{12} $\|S_{12}\|$	S_{12} $\angle\phi$	S_{22} $\|S_{22}\|$	S_{22} $\angle\phi$
5.0	10	100	0.65	-101	16.61	125	0.047	46	0.61	-56
		300	0.64	-160	6.61	96	0.064	39	0.27	-87
		500	0.66	-178	4.01	83	0.078	45	0.19	-98
		700	0.68	171	2.93	73	0.093	49	0.16	-108
		1000	0.68	160	2.07	63	0.119	53	0.16	-124
		1500	0.72	143	1.43	50	0.158	54	0.21	-141
	25	100	0.60	-129	22.41	115	0.034	44	0.49	-84
		300	0.63	-172	7.94	93	0.049	50	0.26	-132
		500	0.66	174	4.78	83	0.071	58	0.21	-150
		700	0.67	166	3.45	75	0.092	60	0.20	-164
		1000	0.67	156	2.46	66	0.124	61	0.21	-177
		1500	0.71	140	1.73	54	0.173	60	0.24	175
	50	100	0.59	-147	25.12	109	0.025	46	0.42	-104
		300	0.64	-178	8.47	91	0.046	60	0.28	-151
		500	0.67	171	5.05	83	0.070	65	0.26	-167
		700	0.68	164	3.67	75	0.093	65	0.25	-178
		1000	0.67	154	2.60	67	0.128	65	0.26	170
		1500	0.72	138	1.83	56	0.178	62	0.29	163
10	10	100	0.65	-90	17.47	128	0.040	50	0.67	-41
		300	0.61	-154	7.31	97	0.057	41	0.33	-57
		500	0.62	-174	4.46	84	0.069	46	0.25	-58
		700	0.64	175	3.27	74	0.084	50	0.22	-60
		1000	0.64	163	2.33	64	0.106	54	0.20	-72
		1500	0.69	145	1.56	50	0.140	57	0.22	-96
	25	100	0.57	-116	24.36	119	0.030	48	0.51	-62
		300	0.58	-167	8.10	94	0.045	52	0.20	-89
		500	0.61	178	5.43	83	0.070	58	0.14	-97
		700	0.63	169	3.93	75	0.084	60	0.10	-106
		1000	0.62	159	2.78	66	0.112	61	0.09	-124
		1500	0.67	142	1.91	53	0.156	60	0.12	-140
	50	100	0.55	-132	26.97	112	0.024	47	0.40	-73
		300	0.57	-173	9.32	91	0.042	59	0.16	-104
		500	0.60	174	5.58	82	0.064	64	0.11	-115
		700	0.62	167	4.04	74	0.086	64	0.08	-128
		1000	0.61	158	2.85	66	0.115	64	0.08	-149
		1500	0.67	141	1.96	55	0.158	61	0.12	-158

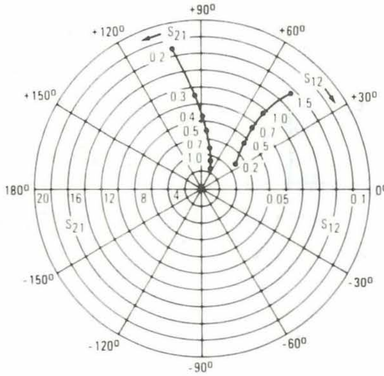
7

MRF962 COMMON-EMITTER S-PARAMETERS

INPUT/OUTPUT REFLECTION COEFFICIENTS versus FREQUENCY
(V_{CE} = 10 V, I_C = 50 mA)



FORWARD/REVERSE TRANSMISSION COEFFICIENTS versus FREQUENCY
(V_{CE} = 10 V, I_C = 50 mA)

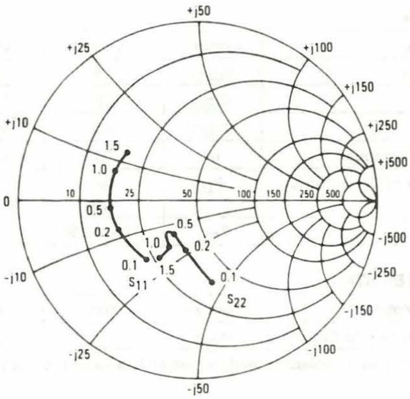


V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11} $\|S_{11}\|$	S_{11} $\angle\phi$	S_{21} $\|S_{21}\|$	S_{21} $\angle\phi$	S_{12} $\|S_{12}\|$	S_{12} $\angle\phi$	S_{22} $\|S_{22}\|$	S_{22} $\angle\phi$
5.0	10	100	0.70	-102	17.42	128	0.044	43	0.65	-57
		300	0.75	-156	7.11	98	0.058	24	0.32	-97
		500	0.78	-170	4.36	86	0.064	25	0.26	-110
		700	0.78	-176	3.16	77	0.071	26	0.23	-117
		1000	0.78	176	2.26	67	0.078	27	0.24	-126
		1500	0.79	167	1.51	54	0.092	29	0.31	-133
	25	100	0.69	-131	24.24	118	0.029	38	0.56	-87
		300	0.77	-167	8.76	95	0.039	32	0.35	-137
		500	0.79	-176	5.26	85	0.046	36	0.32	-150
		700	0.80	178	3.82	78	0.055	40	0.31	-158
		1000	0.79	173	2.72	70	0.067	42	0.32	-164
		1500	0.81	164	1.82	59	0.086	42	0.34	-167
	50	100	0.71	-147	27.72	113	0.021	37	0.53	-107
		300	0.78	-173	9.59	94	0.030	40	0.41	-152
		500	0.81	179	5.72	85	0.038	46	0.39	-163
		700	0.81	176	4.09	78	0.048	50	0.38	-169
		1000	0.81	171	2.89	71	0.061	51	0.38	-175
		1500	0.82	163	1.96	62	0.082	49	0.40	-177
10	10	100	0.71	-92	18.77	131	0.037	47	0.70	-44
		300	0.74	-150	8.09	100	0.051	28	0.34	-69
		500	0.75	-166	5.01	87	0.056	28	0.27	-75
		700	0.76	-174	3.62	78	0.064	28	0.24	-79
		1000	0.76	179	2.58	69	0.071	30	0.24	-88
		1500	0.77	168	1.72	55	0.085	31	0.31	-104
	25	100	0.67	-120	27.10	122	0.027	42	0.57	-68
		300	0.73	-163	10.27	97	0.035	36	0.27	-110
		500	0.76	-174	6.21	86	0.043	39	0.22	-124
		700	0.77	-179	4.48	78	0.051	41	0.20	-132
		1000	0.77	175	3.19	71	0.062	43	0.20	-139
		1500	0.78	166	2.13	59	0.080	42	0.25	-142
	50	100	0.68	-137	31.53	116	0.020	37	0.49	-85
		300	0.74	-169	11.17	95	0.028	40	0.27	-131
		500	0.77	-177	6.69	85	0.037	46	0.24	-144
		700	0.77	178	4.82	78	0.047	48	0.23	-152
		1000	0.77	173	3.42	71	0.059	50	0.23	-158
		1500	0.79	165	2.30	61	0.078	47	0.27	-159

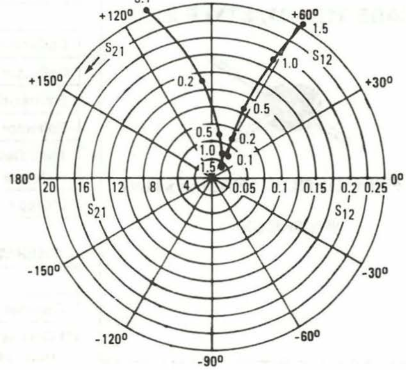
7

MRF965 COMMON-EMITTER S-PARAMETERS

INPUT/OUTPUT REFLECTION COEFFICIENTS versus FREQUENCY (V_{CE} = 10 V, I_C = 50 mA)



FORWARD/REVERSE TRANSMISSION COEFFICIENTS versus FREQUENCY (V_{CE} = 10 V, I_C = 50 mA)



V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11} $\|S_{11}\|$	S_{11} $\angle\phi$	S_{21} $\|S_{21}\|$	S_{21} $\angle\phi$	S_{12} $\|S_{12}\|$	S_{12} $\angle\phi$	S_{22} $\|S_{22}\|$	S_{22} $\angle\phi$
5.0	10	100	0.56	−102	13.87	121	0.054	48	0.58	−62
		300	0.57	−158	5.47	90	0.084	46	0.32	−94
		500	0.56	−169	3.40	77	0.110	52	0.27	−106
		700	0.52	178	2.53	69	0.136	54	0.39	−115
		1000	0.55	167	1.79	57	0.181	56	0.35	−112
		1500	0.54	150	1.27	42	0.242	57	0.43	−122
	25	100	0.48	−129	17.61	112	0.041	51	0.47	−85
		300	0.55	−169	6.38	89	0.076	57	0.30	−125
		500	0.54	−176	3.97	77	0.111	62	0.27	−138
		700	0.50	172	2.94	71	0.114	61	0.30	−143
		1000	0.53	162	2.08	61	0.198	60	0.32	−135
		1500	0.50	146	1.50	47	0.267	57	0.37	−140
	50	100	0.47	−144	19.34	107	0.035	56	0.42	−100
		300	0.55	−173	6.72	87	0.073	63	0.31	−138
		500	0.53	−179	4.17	77	0.112	66	0.29	−150
		700	0.50	168	3.10	71	0.147	64	0.33	−153
		1000	0.53	159	2.19	62	0.206	61	0.32	−146
		1500	0.50	143	1.59	49	0.277	58	0.36	−149
10	10	100	0.56	−92	14.67	123	0.047	50	0.63	−50
		300	0.53	−152	6.00	92	0.077	47	0.34	−73
		500	0.53	−165	3.74	78	0.100	53	0.29	−82
		700	0.49	−177	2.76	70	0.124	56	0.31	−93
		1000	0.52	170	1.96	57	0.166	58	0.38	−94
		1500	0.51	153	1.36	42	0.221	59	0.46	−108
	25	100	0.46	−117	19.10	115	0.036	53	0.49	−68
		300	0.50	−164	7.09	90	0.071	57	0.26	−99
		500	0.49	−172	4.39	78	0.102	62	0.23	−110
		700	0.45	175	3.25	71	0.133	61	0.25	−119
		1000	0.49	164	2.28	60	0.181	61	0.30	−112
		1500	0.47	148	1.61	46	0.246	59	0.37	−120
	50	100	0.42	−131	20.99	110	0.033	56	0.41	−79
		300	0.49	−169	7.46	88	0.069	62	0.24	−111
		500	0.48	−175	4.63	78	0.103	65	0.21	−123
		700	0.45	172	3.40	71	0.136	64	0.25	−129
		1000	0.48	162	2.39	61	0.188	62	0.29	−119
		1500	0.45	146	1.70	48	0.251	59	0.35	−126

BFW92A

CASE 317A-01, STYLE 2

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	2.5	Vdc
Collector Current — Continuous	I_C	35	mAdc
Total Device Dissipation @ T_C = 105°C Derate above 105°C	P_D	180 4.0	mW mW/°C
Storage Temperature	T_{stg}	−65 to 150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case(1)	$R_{\theta JC}$	250	°C/W

(1) Case temperature measured on collector lead immediately adjacent to body of package.

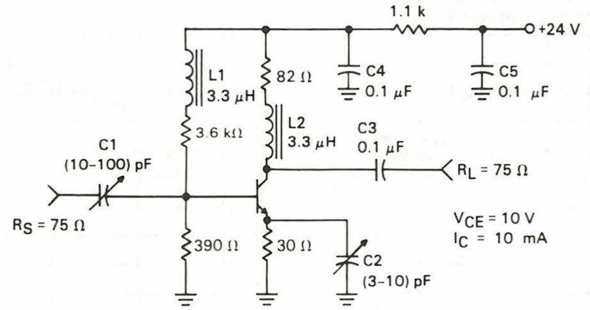
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	25	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	2.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	20	50	150	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)	f_T	—	4.5	—	GHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, f = 1.0 MHz, Emitter Guarded)	C_{cb}	—	0.5	1.0	pF
FUNCTIONAL PERFORMANCE					
Optimum Noise Figure (Tuned) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)	NF_{opt}	—	2.7	—	dB
Noise Figure (Untuned, R_S = R_L = 50 Ω) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)	NF	—	3.0	—	dB
Maximum Available Gain(2) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)	MAG	—	16	—	dB
Insertion Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)	$\|S_{21}\|^2$	—	14	—	dB

(2) $G_{max} = \frac{|S_{21}|^2}{(1 - |S_{11}|^2)(1 - |S_{22}|^2)}$

7

FIGURE 1 — 30-900 MHz BROADBAND AMPLIFIER



C3, C4, C5 — 0.1 μF Chip Capacitor
L1, L2 — 3.3 μH Molded Inductor

All Resistors 1/4 W, 20%

FIGURE 2 — BROADBAND GAIN (Circuit Figure 1)

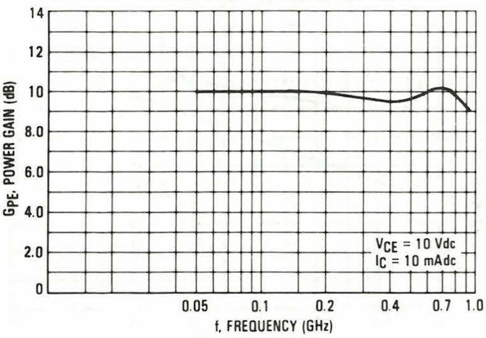


FIGURE 3 — 2nd AND 3rd ORDER INTERCEPT POINTS

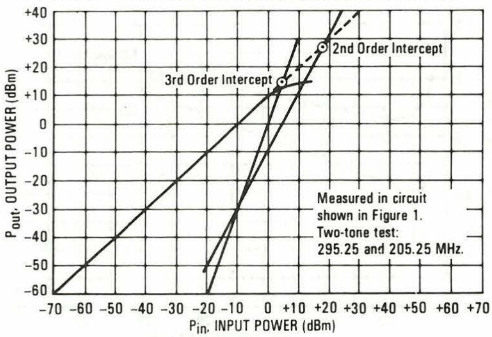


FIGURE 4 — MAXIMUM AVAILABLE GAIN versus FREQUENCY

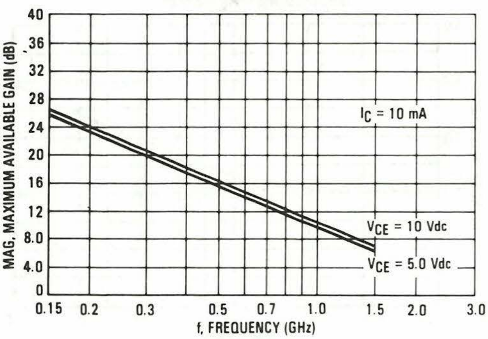


FIGURE 5 — $|S_{21}|^2$ versus FREQUENCY

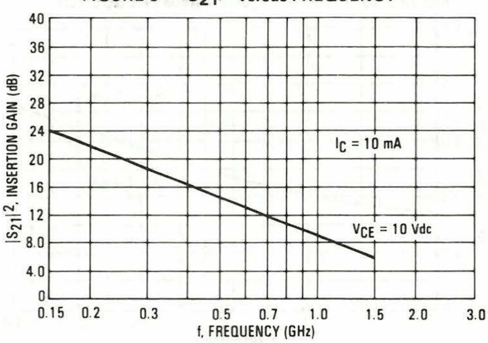


FIGURE 6 — MAXIMUM AVAILABLE GAIN versus COLLECTOR CURRENT

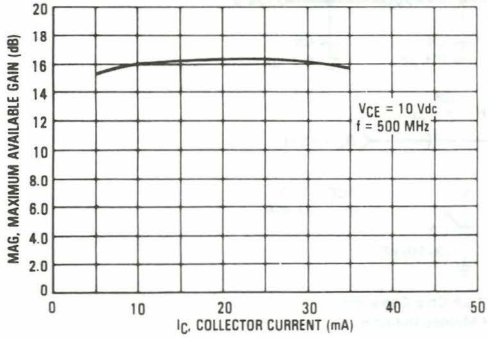


FIGURE 7 — GAIN-BANDWIDTH PRODUCT versus COLLECTOR CURRENT

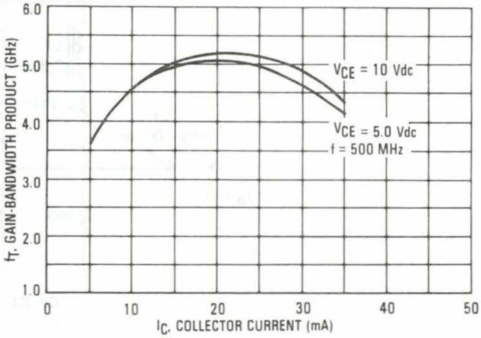


FIGURE 8 — NOISE FIGURE versus COLLECTOR CURRENT

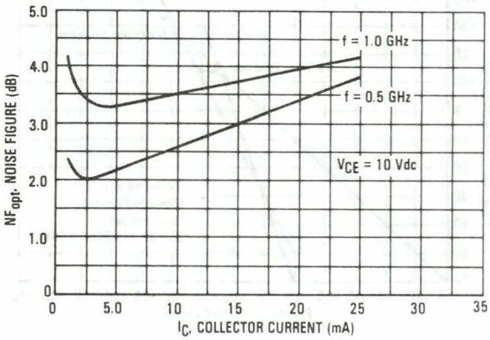
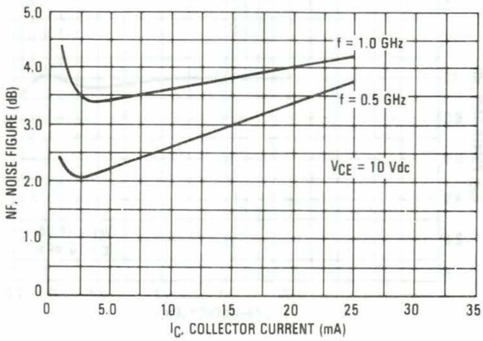


FIGURE 9 — NOISE FIGURE versus COLLECTOR CURRENT Untuned, $R_S = R_L = 50\ \Omega$



7

FIGURE 10 — NOISE FIGURE versus FREQUENCY

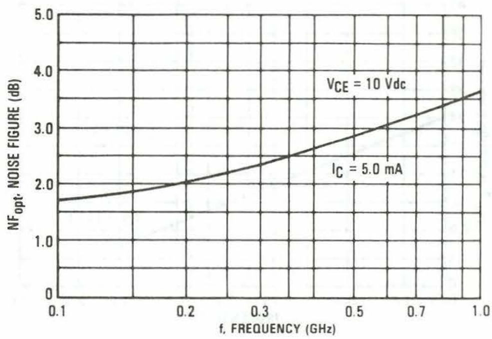


FIGURE 11 — NOISE FIGURE versus FREQUENCY Untuned $R_S = R_L = 50\ \Omega$

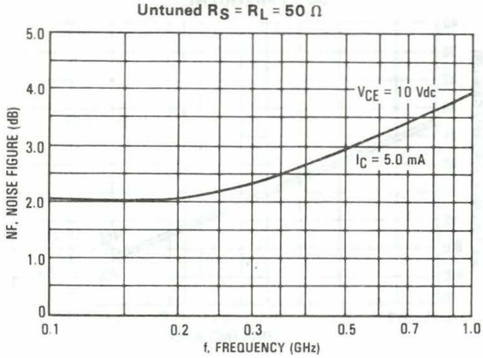


FIGURE 12 — C_{ib} INPUT CAPACITANCE versus EMITTER BASE VOLTAGE

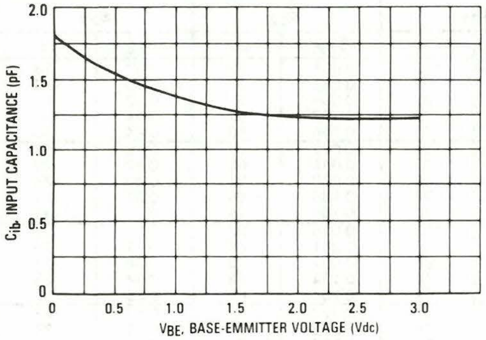
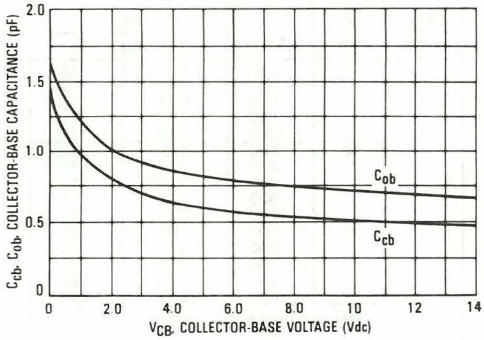
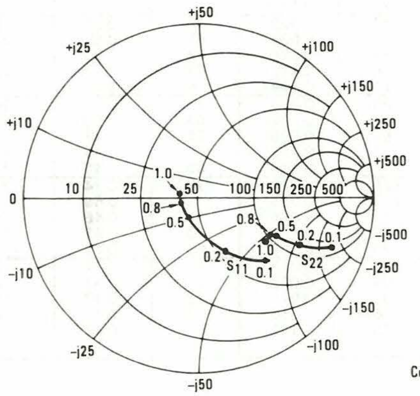


FIGURE 13 — COLLECTOR-BASE CAPACITANCE versus COLLECTOR-BASE VOLTAGE



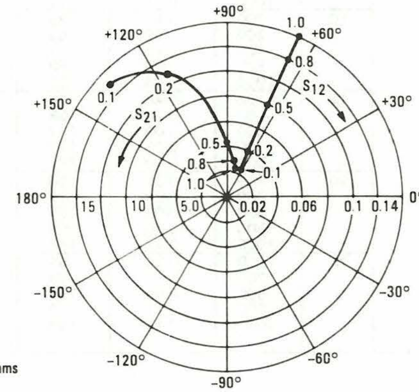
BFW92A COMMON-EMITTER S-PARAMETERS

INPUT/OUTPUT REFLECTION COEFFICIENTS versus FREQUENCY (V_{CE} = 10 V, I_C = 10 mA)



Coordinates in Ohms

FORWARD/REVERSE TRANSMISSION COEFFICIENTS versus FREQUENCY (V_{CE} = 10 V, I_C = 10 mA)



BFW92A COMMON-EMITTER S-PARAMETERS

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11}\rvert$	$\angle\phi$	$\lvert S_{21}\rvert$	$\angle\phi$	$\lvert S_{12}\rvert$	$\angle\phi$	$\lvert S_{22}\rvert$	$\angle\phi$
5.0	5.0	100	0.71	-33	11.2	145	0.031	69	0.87	-18
		200	0.49	-60	8.6	122	0.052	62	0.70	-26
		500	0.21	-119	4.5	92	0.094	61	0.48	-30
		800	0.17	-161	3.0	78	0.137	60	0.44	-36
		1000	0.16	176	2.5	71	0.164	60	0.44	-40
	10	100	0.52	-46	16.6	135	0.027	67	0.78	-23
		200	0.31	-75	11.2	113	0.044	65	0.58	-29
		500	0.14	-150	5.2	88	0.089	67	0.40	-29
		800	0.15	173	3.3	76	0.135	65	0.37	-34
		1000	0.16	154	2.8	70	0.164	64	0.37	-38
	15	100	0.40	-55	19.7	129	0.025	69	0.72	-26
		200	0.22	-88	12.1	109	0.041	68	0.52	-29
		500	0.14	-170	5.4	86	0.087	70	0.36	-27
		800	0.16	161	3.5	76	0.134	68	0.34	-33
		1000	0.17	145	2.9	69	0.164	66	0.35	-37
	20	100	0.33	-62	21.1	125	0.023	69	0.68	-27
		200	0.18	-99	12.5	106	0.039	69	0.49	-28
		500	0.14	178	5.5	85	0.086	72	0.35	-26
		800	0.17	155	3.5	75	0.133	69	0.33	-32
		1000	0.18	142	2.9	69	0.164	67	0.34	-37
	25	100	0.27	-69	21.9	122	0.022	70	0.65	-27
		200	0.15	-111	12.7	104	0.038	71	0.47	-27
		500	0.16	172	5.5	85	0.085	73	0.35	-25
		800	0.19	153	3.5	75	0.132	70	0.33	-31
		1000	0.20	140	2.9	69	0.163	68	0.33	-36
10	5.0	100	0.73	-30	11.1	146	0.026	71	0.90	-14
		200	0.53	-52	8.8	124	0.044	63	0.75	-21
		500	0.21	-98	4.7	94	0.082	62	0.57	-25
		800	0.14	-136	3.1	80	0.120	62	0.53	-30
		1000	0.11	-161	2.6	73	0.143	62	0.53	-34
	10	100	0.57	-39	16.7	137	0.023	70	0.82	-18
		200	0.35	-62	11.5	115	0.038	66	0.65	-23
		500	0.12	-117	5.4	89	0.078	69	0.50	-23
		800	0.09	-163	3.5	78	0.118	67	0.47	-28
		1000	0.09	168	2.9	71	0.144	66	0.48	-32
	15	100	0.46	-46	19.9	130	0.021	70	0.77	-20
		200	0.26	-68	12.6	110	0.035	68	0.60	-22
		500	0.09	-137	5.6	87	0.076	71	0.47	-21
		800	0.09	177	3.7	77	0.117	69	0.45	-27
		1000	0.10	153	3.0	71	0.143	68	0.46	-31
	20	100	0.39	-50	21.5	126	0.020	70	0.74	-21
		200	0.21	-73	13.0	107	0.034	71	0.58	-21
		500	0.08	-154	5.7	86	0.075	72	0.46	-20
		800	0.10	168	3.7	76	0.117	70	0.45	-27
		1000	0.11	148	3.0	71	0.142	69	0.45	-31
	25	100	0.34	-54	22.3	123	0.019	70	0.71	-20
		200	0.17	-79	13.0	105	0.033	71	0.57	-20
		500	0.08	-166	5.7	86	0.075	73	0.47	-19
		800	0.11	162	3.7	76	0.116	70	0.45	-26
		1000	0.13	144	3.0	70	0.141	69	0.46	-30

BFX89
BFY90

CASE 20-03, STYLE 10
TO-72 (TO-206AF)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	2.5	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Continuous Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)		$V_{(BR)CEO}$	15	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)		I_{CBO}	—	—	10	nAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				—
(I_C = 2.0 mAdc, V_{CE} = 1.0 Vdc)			25	—	150	
(I_C = 25 mAdc, V_{CE} = 1.0 Vdc)			20	—	125	
SMALL SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product(1)		f_T				GHz
(I_C = 2.0 mA, V_{CE} = 5.0 Vdc, f = 500 MHz)	BFX89		—	1.0	—	
	BFY90		1.0	—	—	
(I_C = 25 mA, V_{CE} = 5.0 Vdc, f = 500 MHz)	BFX89		—	1.1	—	
	BFY90		1.3	—	—	
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	BFY90	C_{ibo}	—	—	2.0	pF
Collector-Base Capacitance(2)		C_{cb}				pF
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	BFX89		—	0.85	1.7	
	BFY90		—	0.85	1.5	
FUNCTIONAL TEST						
Common-Emitter Amplifier Power Gain(1)		G_{pe}				dB
(V_{CE} = 10 Vdc, I_C = 8.0 mA, f = 200 MHz)	BFX89		19	—	—	
	BFY90		—	21	—	
Spot Noise Figure (R_S = Optimum)(1)		NF				dB
(V_{CE} = 5.0 Vdc, I_C = 2.0 mA, f = 500 MHz)	BFX89		—	2.5	6.5	
	BFY90		—	2.5	5.0	

(1) Pin 4 is grounded.
(2) Pin 4 is not grounded.

FIGURE 1 — POWER GAIN versus FREQUENCY

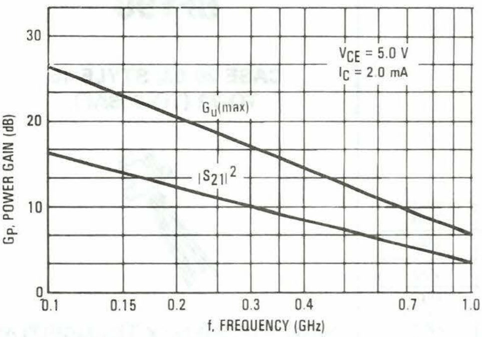


FIGURE 2 — POWER GAIN versus COLLECTOR CURRENT

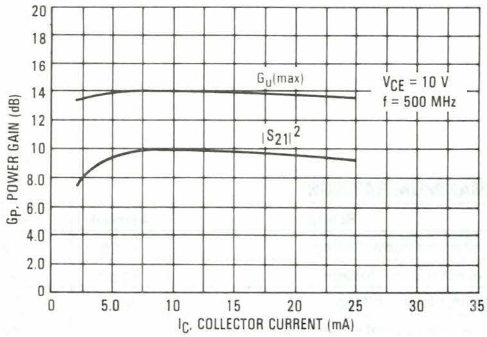


FIGURE 3 — NOISE FIGURE versus FREQUENCY

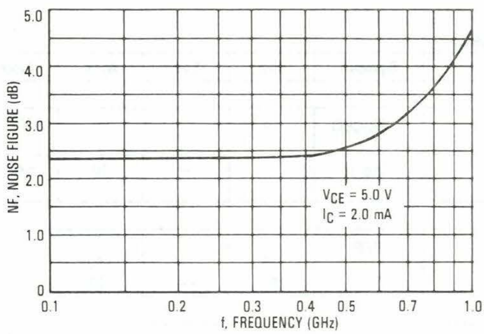
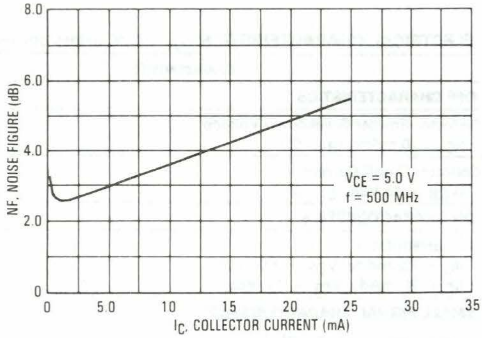


FIGURE 4 — NOISE FIGURE versus COLLECTOR CURRENT



7

FIGURE 5 — CURRENT GAIN-BANDWIDTH PRODUCT versus COLLECTOR CURRENT

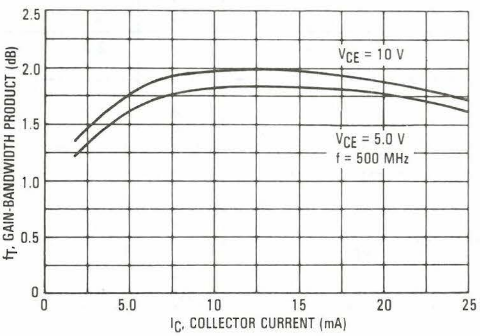
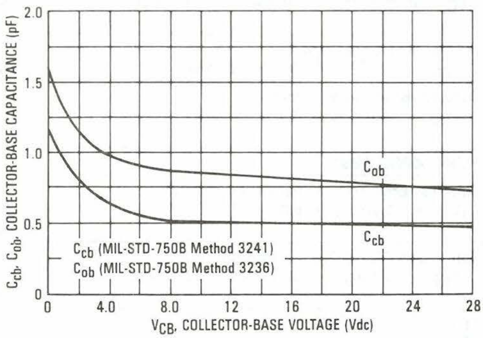
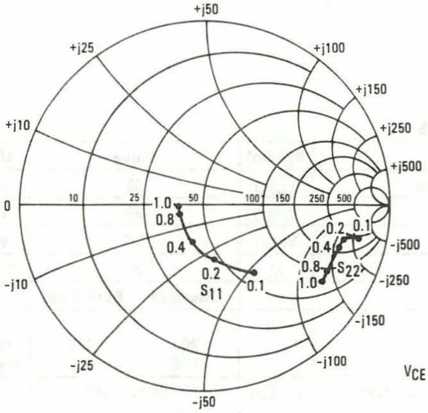


FIGURE 6 — OUTPUT CAPACITANCE versus VOLTAGE



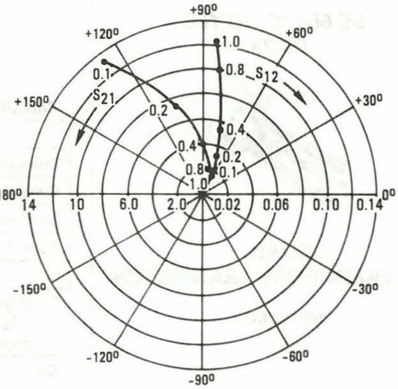
COMMON EMITTER SCATTERING PARAMETERS

FIGURE 7 — INPUT AND OUTPUT REFLECTION COEFFICIENTS versus FREQUENCY



Coordinates in Ohms

FIGURE 8 — FORWARD AND REVERSE TRANSMISSION COEFFICIENTS versus FREQUENCY



V_{CE} = 10 V, I_C = 10 mA

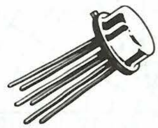
S — PARAMETERS

V_{CE} (Volts)	I_C (mA)	Frequency (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11}\rvert$	$\angle\phi$	$\lvert S_{21}\rvert$	$\angle\phi$	$\lvert S_{12}\rvert$	$\angle\phi$	$\lvert S_{22}\rvert$	$\angle\phi$
5.0	2.0	100	0.81	-37	5.76	148	0.031	72	0.95	-11
		200	0.64	-66	4.56	127	0.050	63	0.87	-17
		400	0.41	-105	2.91	102	0.071	62	0.79	-23
		800	0.26	-157	1.63	77	0.105	74	0.75	-34
		1000	0.23	179	1.38	68	0.129	80	0.74	-41
	5.0	100	0.60	-54	9.73	133	0.026	68	0.87	-13
		200	0.41	-84	6.33	112	0.040	66	0.78	-17
		400	0.26	-121	3.54	92	0.064	72	0.73	-21
		800	0.19	-169	1.89	72	0.112	80	0.72	-31
		1000	0.17	168	1.59	64	0.140	82	0.71	-39
	10	100	0.71	-66	12.13	122	0.022	70	0.81	-14
		200	0.28	-96	7.11	104	0.036	71	0.73	-15
		400	0.19	-133	3.85	88	0.064	77	0.70	-19
		800	0.18	-178	2.00	69	0.115	83	0.71	-30
		1000	0.17	160	1.66	61	0.143	84	0.70	-37
	25	100	0.26	-88	12.79	112	0.019	73	0.76	-13
		200	0.20	-122	7.04	97	0.034	76	0.71	-13
		400	0.20	-156	3.68	83	0.062	81	0.70	-18
		800	0.23	165	1.88	65	0.114	86	0.71	-30
		1000	0.24	146	1.56	58	0.145	88	0.70	-38
10	2.0	100	0.83	-34	5.82	150	0.025	73	0.96	-9
		200	0.66	-61	4.60	129	0.042	65	0.89	-15
		400	0.42	-97	2.98	104	0.059	64	0.83	-20
		800	0.25	-147	1.69	79	0.088	77	0.80	-31
		1000	0.20	-172	1.42	70	0.108	82	0.79	-38
	5.0	100	0.63	-48	9.94	135	0.021	70	0.90	-11
		200	0.43	-76	6.54	114	0.034	68	0.82	-15
		400	0.26	-108	3.72	94	0.054	73	0.77	-19
		800	0.16	-155	1.98	74	0.095	83	0.77	-24
		1000	0.14	180	1.65	66	0.119	85	0.76	-36
	10	100	0.47	-57	12.42	125	0.019	70	0.85	-12
		200	0.30	-83	7.43	106	0.031	72	0.78	-14
		400	0.19	-113	4.04	90	0.054	78	0.75	-18
		800	0.14	-160	2.09	71	0.098	84	0.75	-28
		1000	0.13	173	1.73	64	0.121	86	0.75	-35
	25	100	0.32	-71	13.05	114	0.017	72	0.81	-11
		200	0.21	-99	7.27	99	0.029	76	0.77	-12
		400	0.16	-135	3.81	85	0.052	81	0.76	-16
		800	0.17	177	1.96	68	0.096	87	0.76	-28
		1000	0.18	154	1.62	61	0.120	89	0.76	-35

7

MD4957

CASE 654-02, STYLE 1
TO-78



DUAL
HIGH FREQUENCY TRANSISTOR

PNP SILICON

7

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CBO}	30		Vdc
Emitter-Base Voltage	V_{EBO}	3.0		Vdc
Collector Current	I_C	30		mAdc
		One Side	**Both Sides**	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.15	400 2.3	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	—	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	—	150	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	1000	1500	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	—	0.4	0.8	pF
Small Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	20	—	200	—
Collector Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 10 Vdc, f = 63.6 MHz)	$r_b'C_c$	—	4.0	8.0	ps
Noise Figure (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 450 MHz) (Figure 1) (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, R_S = 50 ohms, f = 1.0 GHz)	NF	 — —	 2.6 5.0	 — —	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (V_{CE} = 10 Vdc, I_C = 2.0 mAdc, f = 450 MHz) (Figure 1) (V_{CE} = 10 Vdc, I_C = 2.0 mAdc, R_S = 50 ohms, f = 1.0 GHz)	G_{pe}	 — —	 18 13	 — —	dB

TYPICAL NOISE FIGURE vs. FREQUENCY

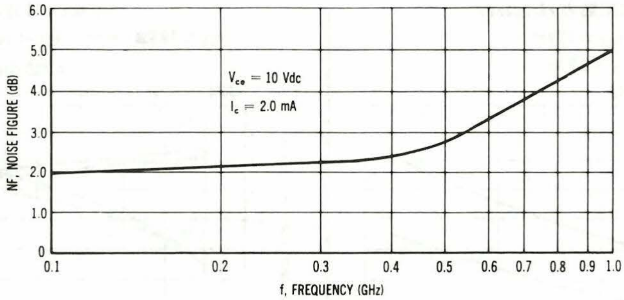
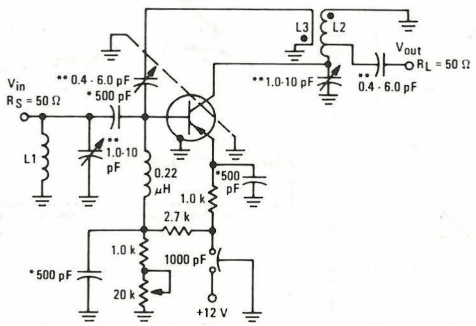


FIGURE 1 — NOISE FIGURE AND POWER GAIN TEST CIRCUIT



* Button type capacitors
** Variable air piston type capacitors

1. L1 - silver plated brass bar, 1.0 in. lg by 0.25 in od.
2. L2 - silver plated brass bar, 1.5 in. lg by 0.25 in od. Tap is 0.25 in. from collector
3. L3 - ½ turn of AWG No. 16 wire 0.25 in. from and parallel to L2.
4. The noise source is a hot-cold body (All type 70 or equivalent) with a test receiver (AIL type 136 or equivalent).

7

COMMON EMITTER Y PARAMETER VARIATIONS

Y PARAMETERS VS FREQUENCY

$V_{CE} = 10$ Vdc

$I_C = 2.0$ mA

FIGURE 2 — INPUT ADMITTANCE

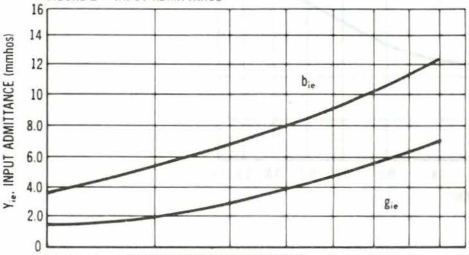


FIGURE 3 — FORWARD TRANSFER ADMITTANCE

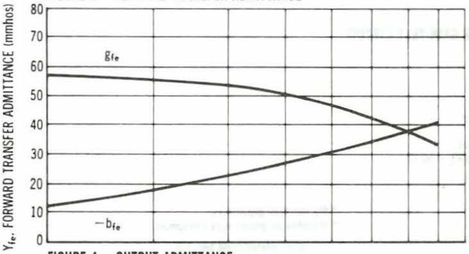


FIGURE 4 — OUTPUT ADMITTANCE

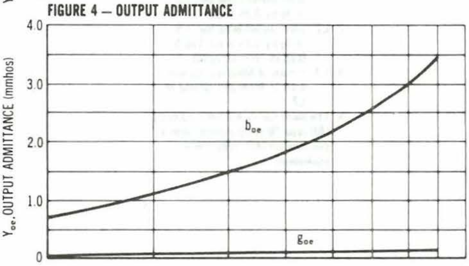
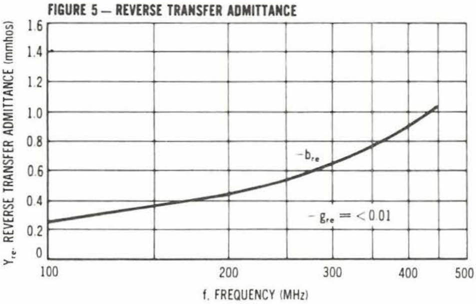


FIGURE 5 — REVERSE TRANSFER ADMITTANCE



Y PARAMETERS VS CURRENT

$V_{CE} = 10$ Vdc ——— $V_{CE} = 15$ Vdc — — —

f = 450 MHz

FIGURE 6 — INPUT ADMITTANCE

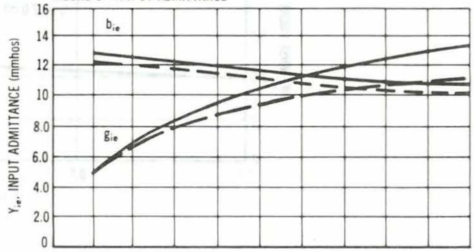


FIGURE 7 — FORWARD TRANSFER ADMITTANCE

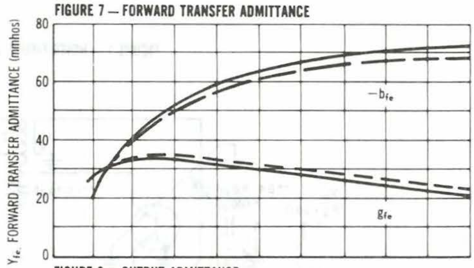


FIGURE 8 — OUTPUT ADMITTANCE

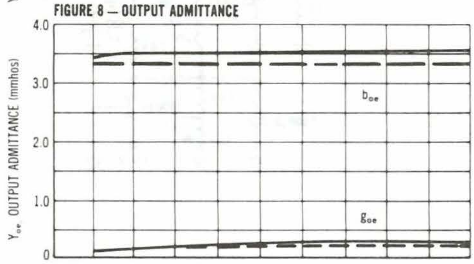
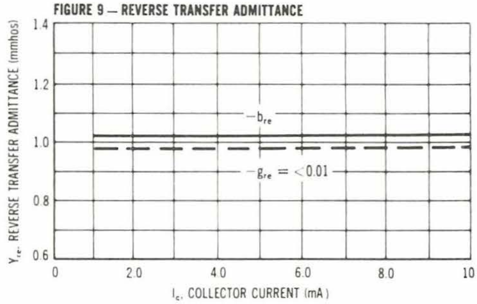


FIGURE 9 — REVERSE TRANSFER ADMITTANCE



COMMON BASE Y PARAMETER VARIATIONS

Y PARAMETERS versus FREQUENCY

V_{CB} = 10 Vdc

I_C = 2.0 mA

FIGURE 10 — INPUT ADMITTANCE

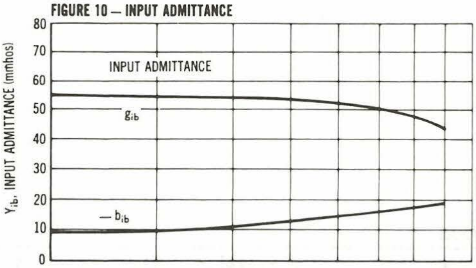


FIGURE 11 — FORWARD TRANSFER ADMITTANCE

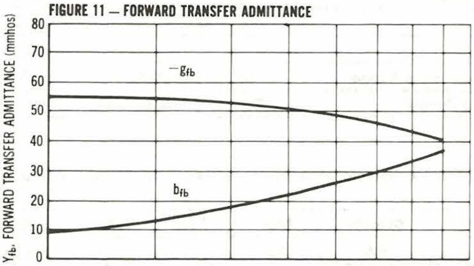


FIGURE 12 — OUTPUT ADMITTANCE

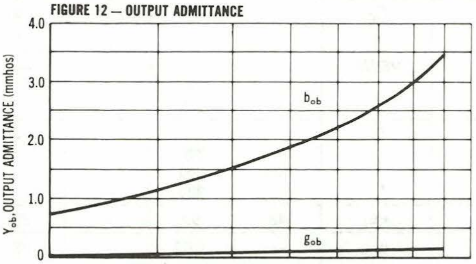
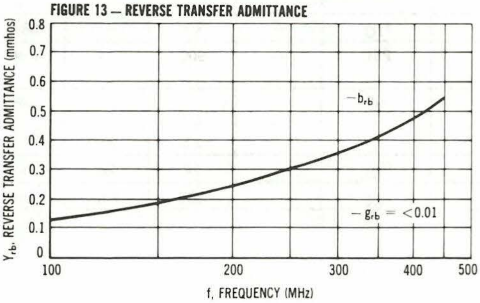


FIGURE 13 — REVERSE TRANSFER ADMITTANCE



Y PARAMETERS versus CURRENT

V_{CB} = 10 Vdc ——— V_{CB} = 15 Vdc — — —

f = 450 MHz

FIGURE 14 — INPUT ADMITTANCE

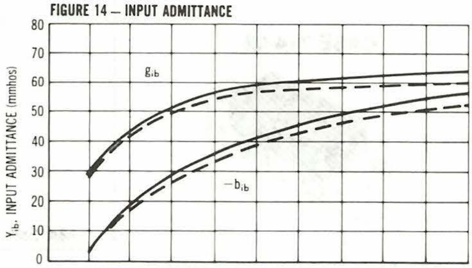


FIGURE 15 — FORWARD TRANSFER ADMITTANCE

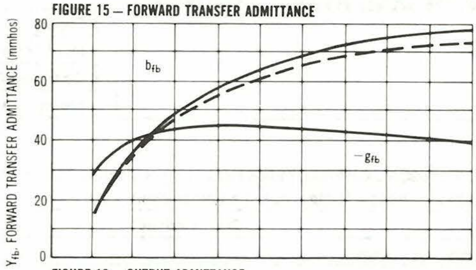


FIGURE 16 — OUTPUT ADMITTANCE

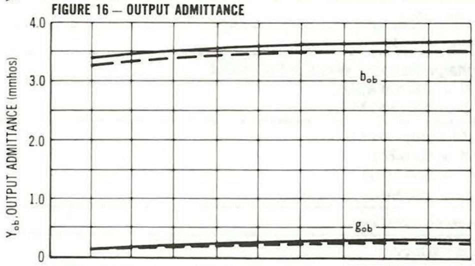
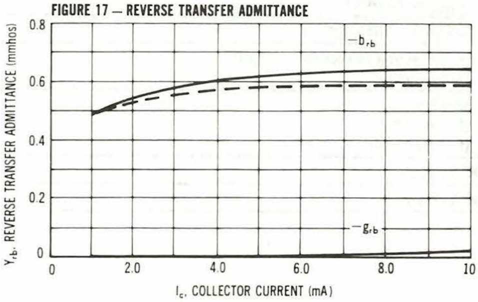
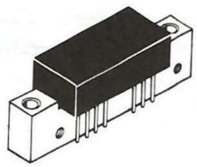


FIGURE 17 — REVERSE TRANSFER ADMITTANCE



MHW590

CASE 714-02



WIDEBAND HYBRID AMPLIFIER

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_{DC}	28	Vdc
Input Power	P_{in}	5.0	dBm
Operating Case Temperature Range	T_C	−20 to +90	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{DC} = 24 Vdc, Z_o = 50 Ω, T_C = 25°C. All characteristics guaranteed over bandwidth listed under "Frequency Range," unless specified otherwise.)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	10	—	400	MHz
Power Gain	G_p	31.5	34	35.5	dB
Gain Flatness	F	—	—	±1.5	dB
Voltage Standing Wave Ratio, In/Out (f = 10–300 MHz) (f = 300–400 MHz)	VSWR	 — —	 1.5:1 2:1	 — —	—
1 dB Compression (f = 10 MHz) (f = 200 MHz) (f = 400 MHz)	P1	 — 700 —	 800 800 300	 — — —	mW
Reverse Isolation	P_{RI}	43	50	—	dB
2nd Harmonic (P_{out} = 10 mW)	d_{so}	—	−66	—	dB
Third Order Intercept	I_{TO}	—	43	—	dBm
Peak Envelope Power for −32 dB Distortion	PEP	—	500	—	mW
Noise Figure (f = 60 MHz) (f = 300 MHz)	NF	 — —	 4.0 3.5	 — 5.5	dB
DC Voltage	V_{DC}	—	24	28	V
DC Current	I_{DC}	—	300	340	mA

FIGURE 1 — POWER GAIN AND RETURN LOSS versus FREQUENCY

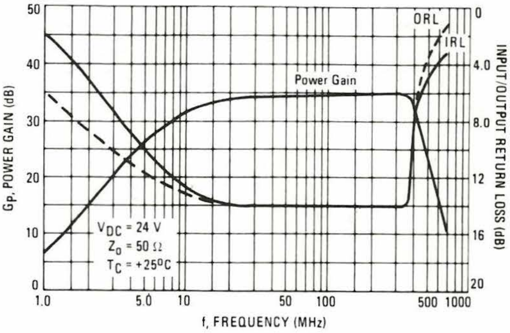


FIGURE 2 — POWER GAIN versus FREQUENCY

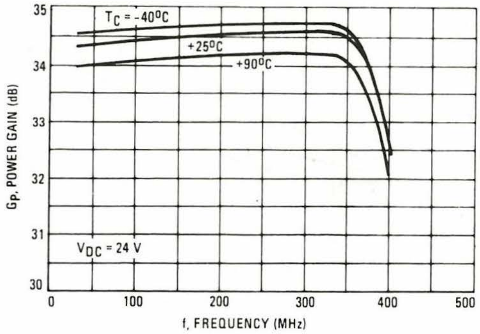


FIGURE 3 — POWER GAIN versus SUPPLY VOLTAGE

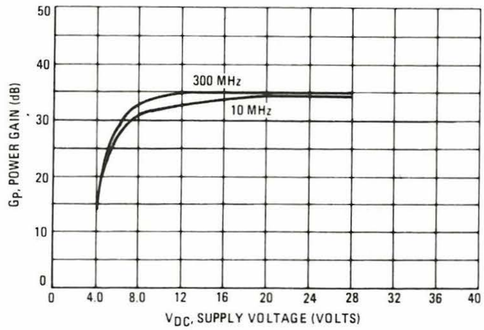


FIGURE 4 — NOISE FIGURE versus SUPPLY VOLTAGE

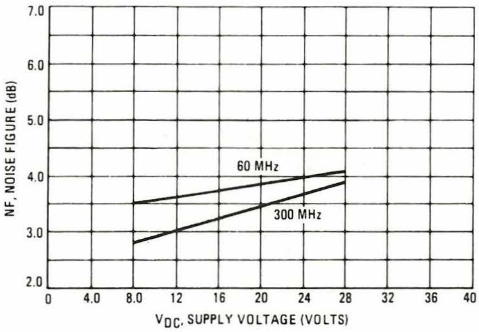


FIGURE 5 — OUTPUT POWER versus INPUT POWER

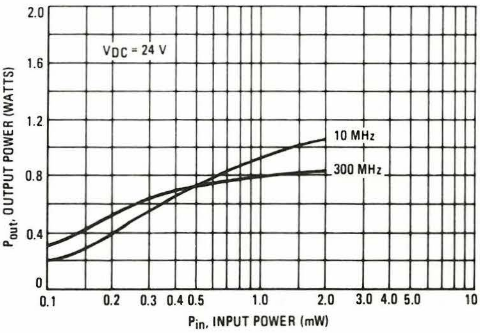
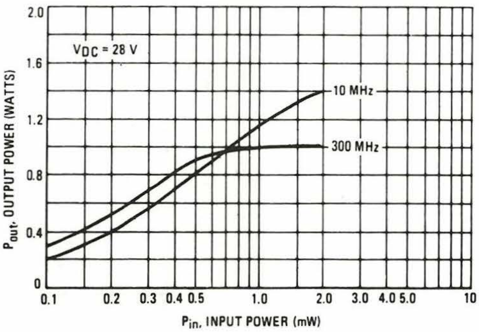


FIGURE 6 — OUTPUT POWER versus INPUT POWER



7

FIGURE 7 — INTERMODULATION DISTORTION — THIRD ORDER versus OUTPUT POWER

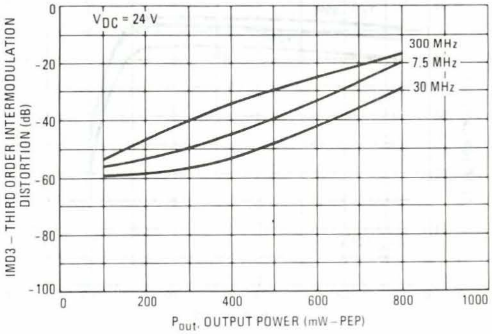


FIGURE 8 — INTERMODULATION DISTORTION — FIFTH ORDER versus OUTPUT POWER

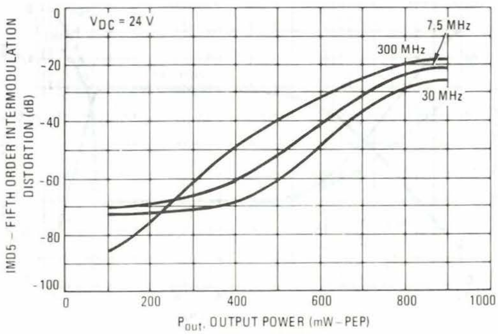


FIGURE 9 — INTERMODULATION DISTORTION — THIRD ORDER versus OUTPUT POWER

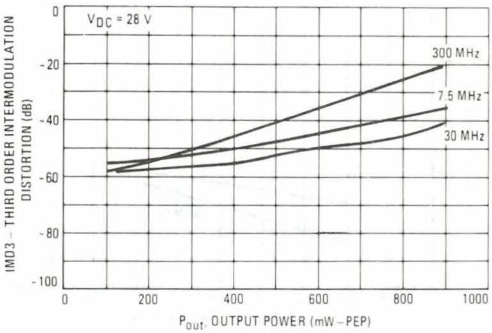


FIGURE 10 — INTERMODULATION DISTORTION — FIFTH ORDER versus OUTPUT POWER

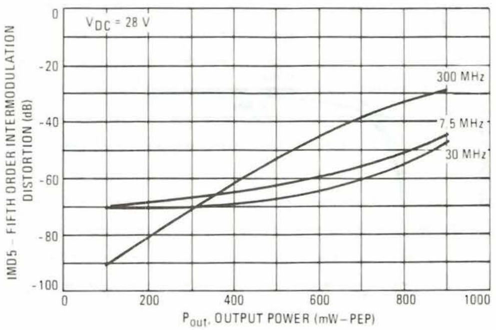
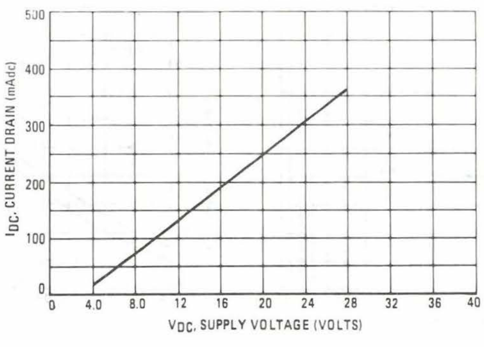
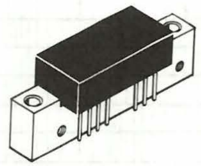


FIGURE 11 — DC CURRENT DRAIN versus SUPPLY VOLTAGE



MHW591

CASE 714-02



WIDEBAND HYBRID AMPLIFIER

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_{DC}	16	Vdc
Input Power	P_{in}	3.0	dBm
Operating Case Temperature Range	T_C	−20 to +90	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{DC} = 13.6 Vdc, Z_o = 50 Ω, T_C = 25°C. All characteristics guaranteed over bandwidth listed under "Frequency Range," unless specified otherwise.)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	1.0	—	250	MHz
Power Gain	G_p	34.5	36.5	38	dB
Gain Flatness	F	—	—	±1.5	dB
Voltage Standing Wave Ratio, In/Out	VSWR				—
(f = 1.0–30 MHz)		—	1.5:1	—	
(f = 30–250 MHz)		—	2:1	—	
1 dB Compression	P1				mW
(f = 30 MHz)		650	800	—	
(f = 100 MHz)		—	700	—	
(f = 250 MHz)		—	250	—	
Peak Envelope Power	PEP				mW
(IMD3 = −30 dB, f = 30 MHz)		700	850	—	
(IMD3 = −30 dB, f = 100 MHz)		—	600	—	
(IMD3 = −30 dB, f = 250 MHz)		—	300	—	
Noise Figure	NF				dB
(f = 30 MHz)		—	3.7	5.0	
(f = 100 MHz)		—	3.7	—	
(f = 250 MHz)		—	4.5	—	
DC Voltage	V_{DC}	—	13.6	16	V
DC Current	I_{DC}	—	300	340	mA

7

FIGURE 1 – POWER GAIN versus FREQUENCY

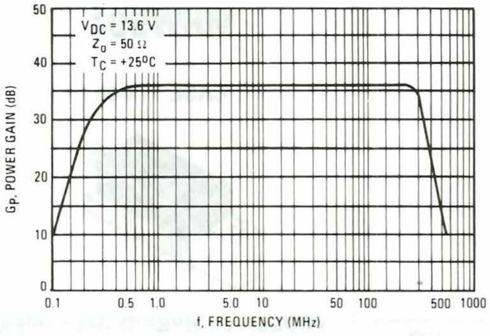


FIGURE 2 – POWER GAIN versus FREQUENCY

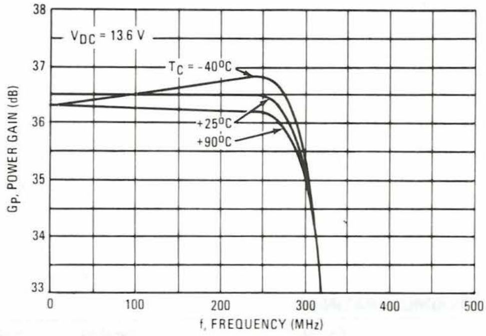


FIGURE 3 – POWER GAIN versus SUPPLY VOLTAGE

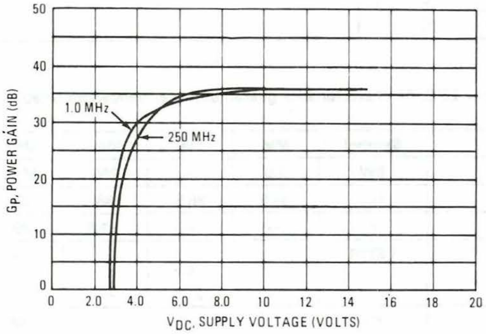


FIGURE 4 – NOISE FIGURE versus SUPPLY VOLTAGE

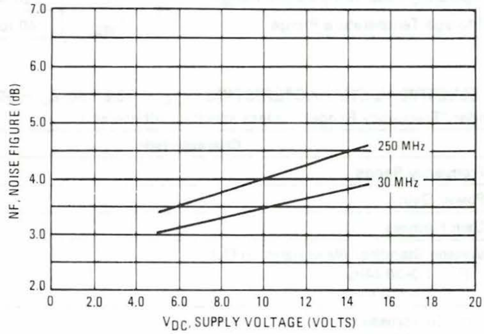


FIGURE 5 – OUTPUT POWER versus INPUT POWER

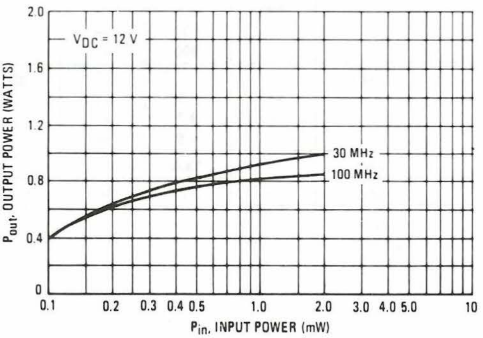


FIGURE 6 – OUTPUT POWER versus INPUT POWER

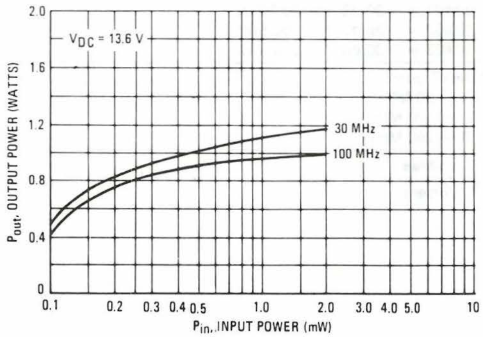


FIGURE 7 – INTERMODULATION DISTORTION versus OUTPUT POWER

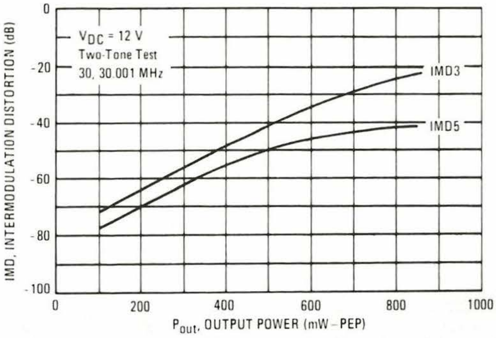


FIGURE 8 – INTERMODULATION DISTORTION versus OUTPUT POWER

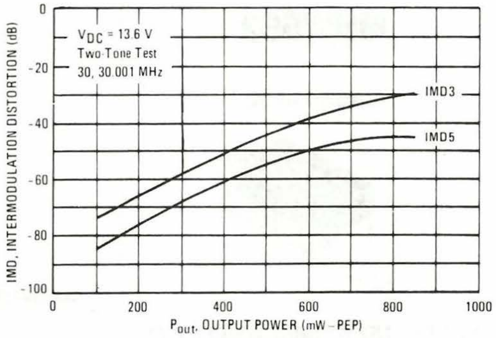
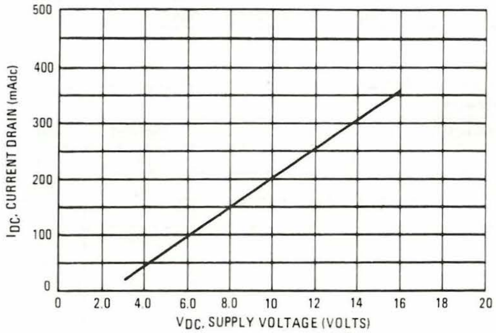


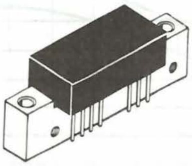
FIGURE 9 – DC CURRENT DRAIN versus SUPPLY VOLTAGE



7

MHW592

CASE 714-02



WIDEBAND HYBRID AMPLIFIER

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_{DC}	28	Vdc
Input Power	P_{in}	5.0	dBm
Operating Case Temperature Range	T_C	−20 to +90	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

7

ELECTRICAL CHARACTERISTICS (V_{DC} = 24 Vdc, Z_o = 50 Ω, T_C = 25°C. All characteristics guaranteed over bandwidth listed under "Frequency Range," unless specified otherwise.)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	1.0	—	250	MHz
Power Gain	G_p	33.5	35	36.5	dB
Gain Flatness	F	—	—	±1.0	dB
Voltage Standing Wave Ratio, In/Out	VSWR				—
(f = 1.0–30 MHz)		—	1.5:1	—	
(f = 30–250 MHz)		—	2:1	—	
1 dB Compression	P1				mW
(f = 30 MHz)		750	900	—	
(f = 100 MHz)		—	900	—	
(f = 250 MHz)		—	750	—	
Peak Envelope Power	PEP				mW
(IMD3 = −30 dB, f = 30 MHz)		700	850	—	
(IMD3 = −30 dB, f = 100 MHz)		—	850	—	
(IMD3 = −30 dB, f = 250 MHz)		—	600	—	
Noise Figure	NF				dB
(f = 30 MHz)		—	3.6	5.0	
(f = 100 MHz)		—	3.7	—	
(f = 250 MHz)		—	3.9	—	
DC Voltage	V_{DC}	—	24	28	V
DC Current	I_{DC}	—	300	340	mA

FIGURE 1 — POWER GAIN versus FREQUENCY

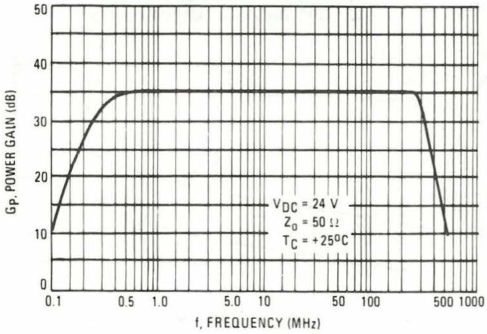


FIGURE 2 — POWER GAIN versus FREQUENCY

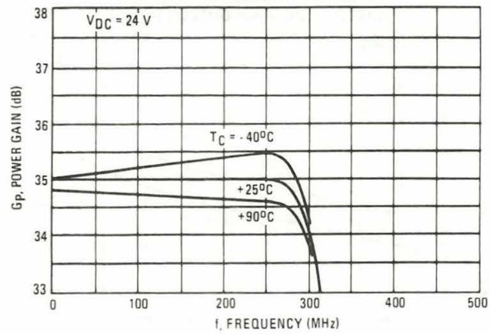


FIGURE 3 — POWER GAIN versus SUPPLY VOLTAGE

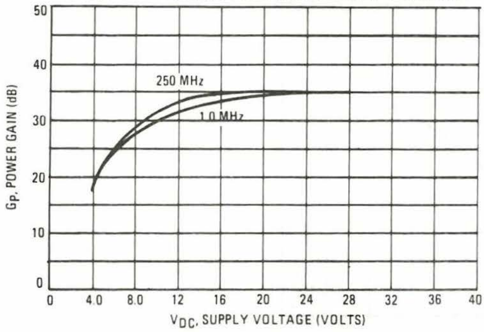


FIGURE 4 — NOISE FIGURE versus SUPPLY VOLTAGE

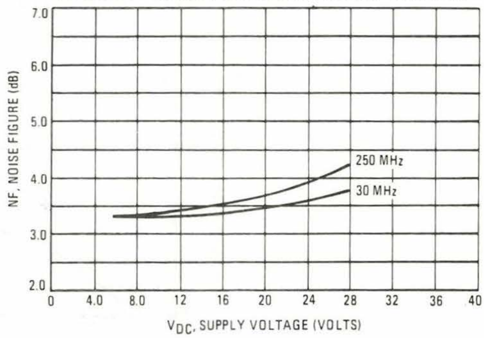


FIGURE 5 — OUTPUT POWER versus INPUT POWER

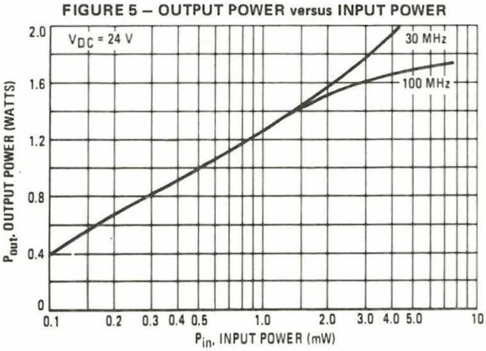
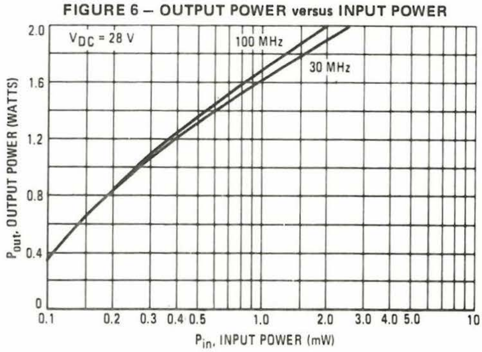


FIGURE 6 — OUTPUT POWER versus INPUT POWER



7

FIGURE 7 – INTERMODULATION DISTORTION versus OUTPUT POWER

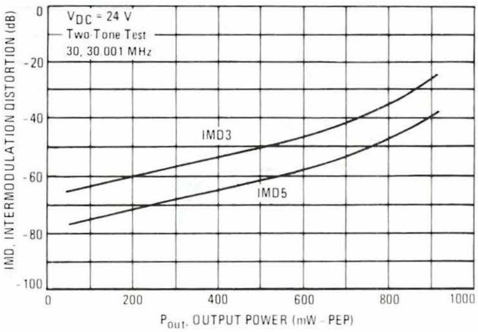


FIGURE 8 – INTERMODULATION DISTORTION versus OUTPUT POWER

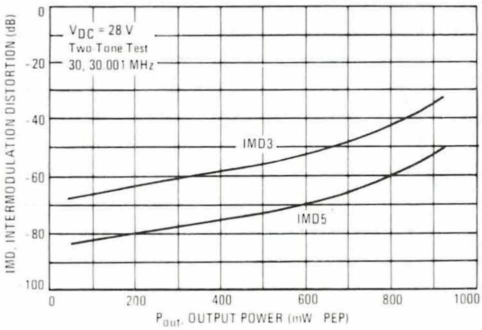
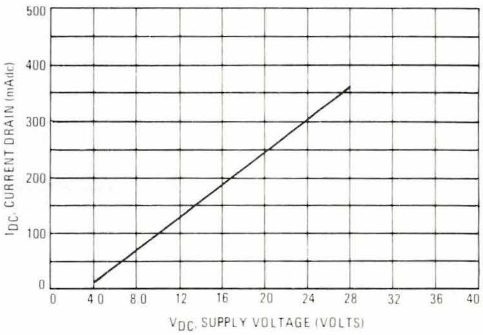


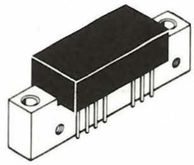
FIGURE 9 – DC CURRENT DRAIN versus SUPPLY VOLTAGE



7

MHW593

CASE 714-02



WIDEBAND HYBRID AMPLIFIER

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_{DC}	16	Vdc
Input Power	P_{in}	3.0	dBm
Operating Case Temperature Range	T_C	−20 to +90	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{DC} = 13.6 Vdc, Z_o = 50 Ω, T_C = 25°C. All characteristics guaranteed over bandwidth listed under "Frequency Range," unless specified otherwise.)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	10	—	400	MHz
Power Gain	G_p	33	34.5	36	dB
Gain Flatness	F	—	—	±1.0	dB
Voltage Standing Wave Ratio, In/Out	VSWR				—
(f = 10–300 MHz)		—	1.5:1	—	
(f = 300–400 MHz)		—	2:1	—	
1 dB Compression	P1				mW
(f = 10 MHz)		—	600	—	
(f = 200 MHz)		500	600	—	
(f = 400 MHz)		—	200	—	
Reverse Isolation	P_{RI}	45	50	—	dB
2nd Harmonic (P_{out} = 10 mW)	d_{so}	—	−55	—	dB
Third Order Intercept	I_{TO}	—	38	—	dBm
Peak Envelope Power for −32 dB Distortion	PEP	—	300	—	mW
Noise Figure	NF				dB
(f = 60 MHz)		—	3.7	—	
(f = 300 MHz)		—	4.0	5.5	
DC Voltage	V_{DC}	—	13.6	16	V
DC Current	I_{DC}	—	300	340	mA

FIGURE 1 – POWER GAIN AND RETURN LOSS versus FREQUENCY

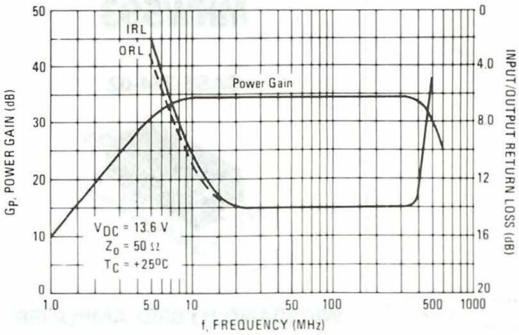


FIGURE 2 – POWER GAIN versus FREQUENCY

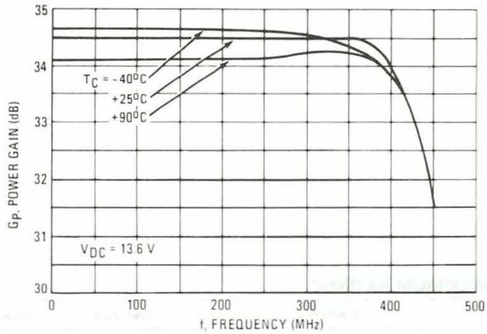


FIGURE 3 – POWER GAIN versus SUPPLY VOLTAGE

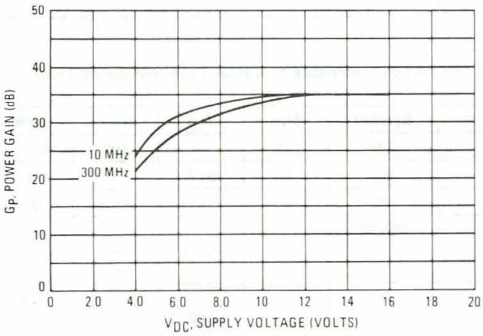


FIGURE 4 – NOISE FIGURE versus SUPPLY VOLTAGE

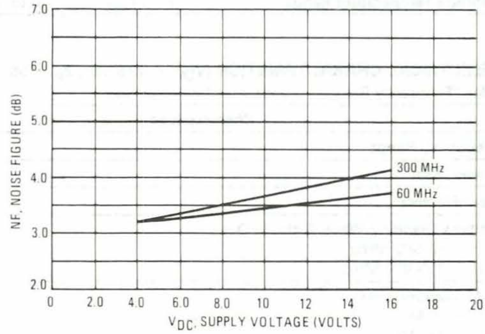


FIGURE 5 – OUTPUT POWER versus INPUT POWER

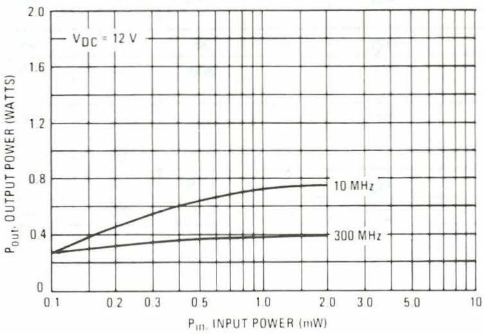


FIGURE 6 – OUTPUT POWER versus INPUT POWER

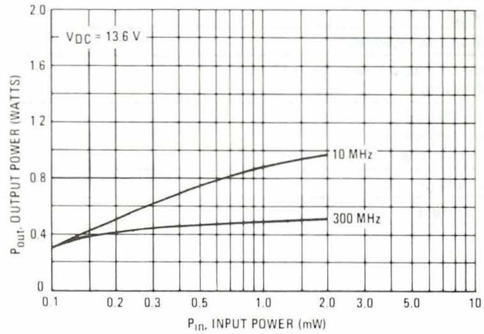


FIGURE 7 – INTERMODULATION DISTORTION – THIRD ORDER versus OUTPUT POWER

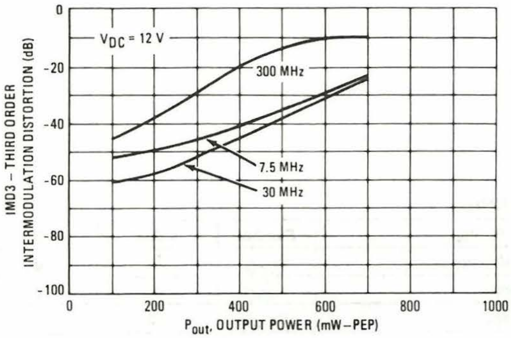


FIGURE 8 – INTERMODULATION DISTORTION – FIFTH ORDER versus OUTPUT POWER

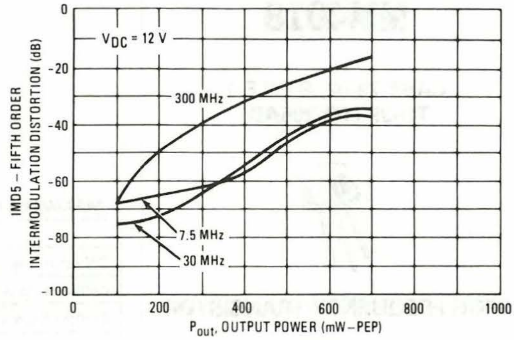


FIGURE 9 – INTERMODULATION DISTORTION – THIRD ORDER versus OUTPUT POWER

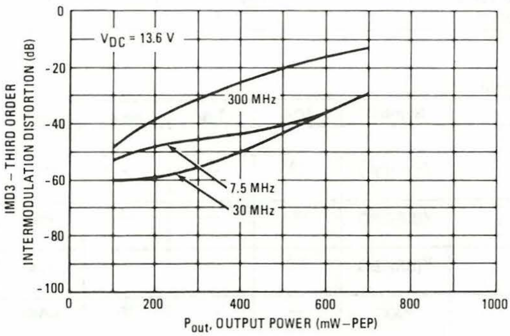


FIGURE 10 – INTERMODULATION DISTORTION – FIFTH ORDER versus OUTPUT POWER

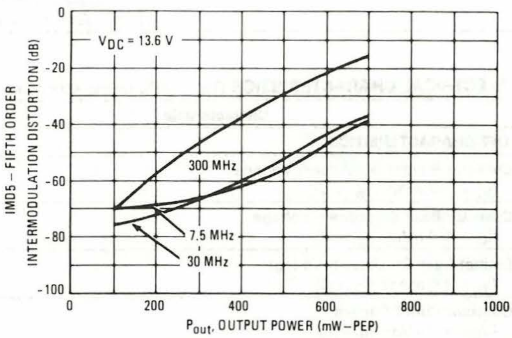
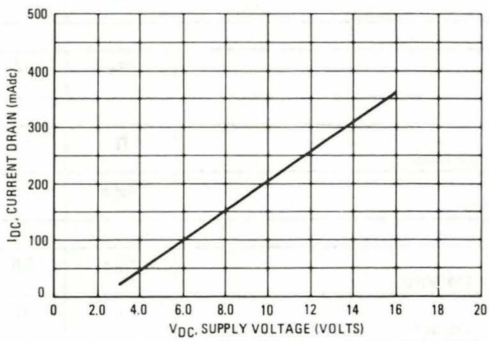


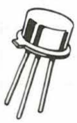
FIGURE 11 – DC CURRENT DRAIN versus SUPPLY VOLTAGE



7

MM4018

CASE 79-02, STYLE 1
TO-39 (TO-205AD)



HIGH FREQUENCY TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	0.4	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

7

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 5.0 mAdc, I_E = 0)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	I_{CEO}	—	—	20	μAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	10	μAdc
Collector Cutoff Current (V_{CE} = 40 Vdc, V_{BE} = 0)	I_{CES}	—	—	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10	—	—	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	f_T	—	900	—	MHz
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	3.5	—	pF
FUNCTIONAL TEST					
Power Output (Figure 1) (P_{in} = 50 mW, V_{CC} = 12.5 Vdc, f = 175 MHz)	P_{out}	0.5	—	—	Watt
Collector Efficiency (Figure 1) (P_{in} = 50 mW, V_{CC} = 12.5 Vdc, f = 175 MHz)	η	45	55	—	%

FIGURE 1 — 175 MHz OUTPUT POWER TEST CIRCUIT

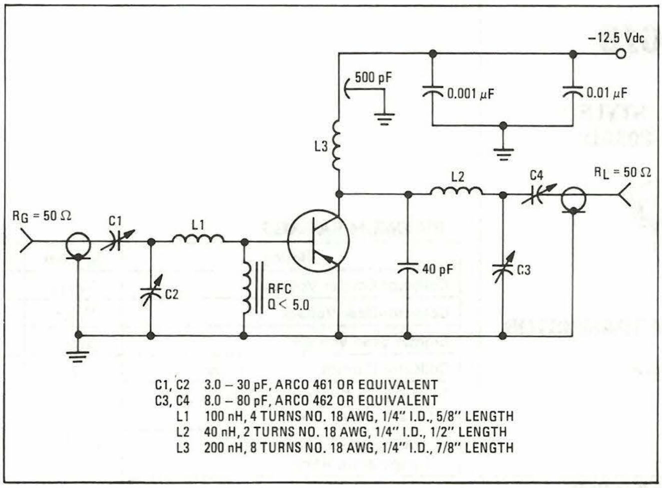


FIGURE 2 — POWER OUTPUT versus POWER INPUT

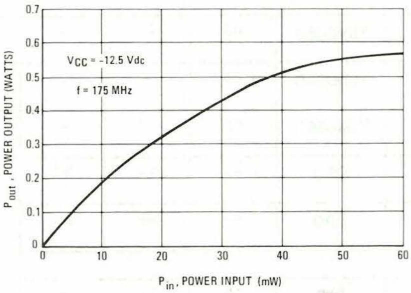


FIGURE 3 — PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

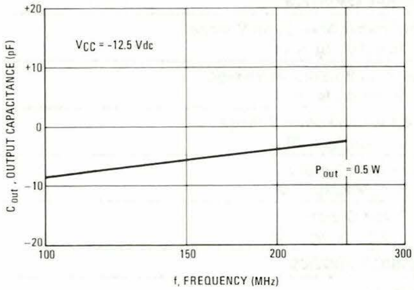


FIGURE 4 — PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

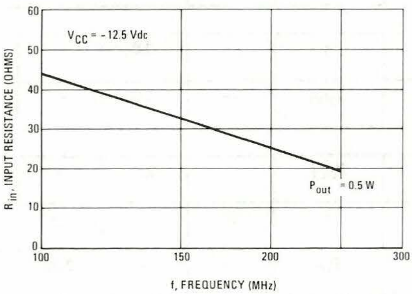
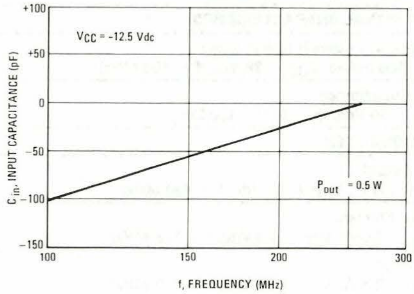


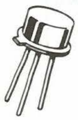
FIGURE 5 — PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY



7

MM4019

CASE 79-02, STYLE 1
TO-39 (TO-205AD)



HIGH FREQUENCY TRANSISTOR

PNP SILICON

Refer to 2N5160 for graphs.

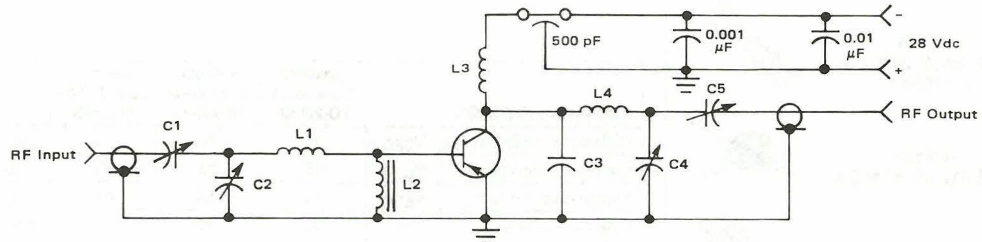
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 mAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 Adc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	—	—	0.1	mAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	—	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10	—	—	—
Collector-Emitter Saturation Voltage (I_C = 250 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	—	—	1.0	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 28 Vdc, f = 100 MHz)	f_T	—	750	—	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 100 kHz)	C_{obo}	—	7.5	—	pF
FUNCTIONAL TEST					
Power Output (P_{in} = 0.5 W, V_{CC} = 28 Vdc, f = 400 MHz)	P_{out}	—	2.0	—	Watts
Collector Efficiency (P_{out} = 2.5 W, V_{CC} = 28 Vdc, f = 175 MHz)	η	50	—	—	%
Power Input (P_{out} = 2.5 W, V_{CC} = 28 Vdc, f = 175 MHz)	P_{in}	—	—	0.25	Watt

FIGURE 1 — 175 MHz TEST CIRCUIT



C1,C2	3.0-30 pF, ARCO 461 or equivalent.
C3	40 pF
C4,C5	5.0-80 pF, ARCO 462 or equivalent.
L1	80 nH, 3 Turns #18 AWG, 1/4" I.D., 1/4" Length
L2	Ferrite Choke, VK-200 Ferroxcube, Q < 5
L3	0.15 μH, RF Choke
L4	27 nH, 2 Turns #18 AWG, 1/4" I.D., 3/8" Length

7

MRF534
MRF536
MM4049

MRF534
CASE 22-03, STYLE 1
TO-206AA

MRF536
CASE 317-01, STYLE 2

MM4049
CASE 20-03, STYLE 2
TO-206AF

HIGH FREQUENCY TRANSISTOR

PNP SILICON

MAXIMUM RATINGS		MM4049 Case 20-03 TO-206AF	MRF534 Case 22-03 TO-206AA	MRF536 Case 317-01 Macro-X	
Collector-Emitter Voltage	V_{CEO}	10	10	10	Vdc
Collector-Base Voltage	V_{CBO}	15	15	15	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	4.5	4.5	Vdc
Collector Current — Continuous	I_C	30	30	30	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	200 1.14	300 1.71	300 2.40	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	−65 to +200	−65 to +150	°C

7

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	10	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		$V_{(BR)CBO}$	15	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	4.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)		I_{CBO}	—	—	10	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 25 mAdc, V_{CE} = 2.0 Vdc)		h_{FE}	20	—	200	—
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 5.0 Vdc, f = 500 MHz)	MRF534, MM4049 MRF536	f_T	4.0 5.0	— —	— —	GHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	—	—	1.3	pF
FUNCTIONAL TEST						
Maximum Available Gain (I_C = 15 mAdc, V_{CE} = 5.0 Vdc, f = 500 MHz) (I_C = 15 mAdc, V_{CE} = 5.0 Vdc, f = 500 MHz) (I_C = 15 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 GHz)	 MRF534 MM4049 MRF536	MAG	 10 11.5 8.5	 12 13 10	 — — —	dB

FIGURE 1 — CURRENT GAIN — BANDWIDTH PRODUCT versus CURRENT

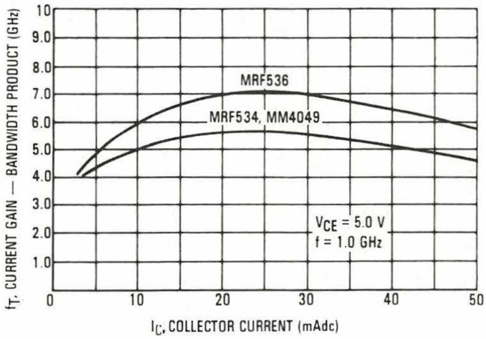


FIGURE 2 — MAXIMUM AVAILABLE GAIN versus COLLECTOR CURRENT

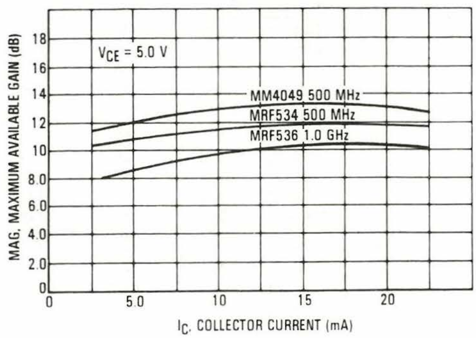
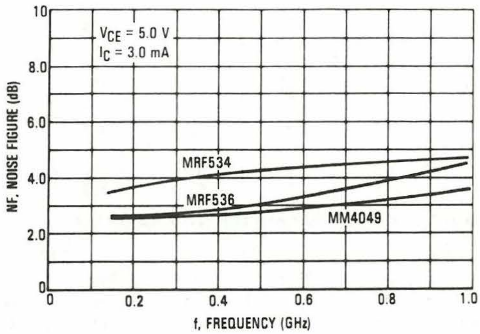


FIGURE 3 — NOISE FIGURE versus FREQUENCY



7

MM4049 COMMON-EMITTER S-PARAMETERS

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	$\angle\phi$	$\|S_{21}\|$	$\angle\phi$	$\|S_{12}\|$	$\angle\phi$	$\|S_{22}\|$	$\angle\phi$
5.0	5.0	200	0.634	-31	6.37	120	0.060	69	0.711	-23
		400	0.469	-34	3.95	93	0.107	65	0.602	-30
		600	0.379	-40	2.90	77	0.147	62	0.587	-33
		800	0.368	-51	2.32	65	0.183	56	0.55	-36
		1000	0.381	-54	1.93	55	0.223	50	0.528	-44
	10	200	0.523	-29	7.79	112	0.056	72	0.632	-23
		400	0.418	-28	3.74	89	0.104	68	0.543	-29
		600	0.344	-34	3.20	74	0.146	65	0.542	-32
		800	0.345	-46	2.54	64	0.184	58	0.513	-34
		1000	0.366	-50	2.09	54	0.225	52	0.493	-42
	20	200	0.454	-25	8.43	106	0.065	73	0.584	-21
		400	0.390	-23	4.67	85	0.105	70	0.513	-27
		600	0.325	-30	3.31	72	0.148	66	0.620	-30
		800	0.327	-44	2.61	62	0.188	59	0.497	-32
		1000	0.351	-48	2.15	52	0.231	52	0.476	-41
10	5.0	200	0.731	-25	5.83	121	0.053	70	0.736	-18
		400	0.589	-30	3.65	95	0.096	67	0.654	-26
		600	0.502	-38	2.71	79	0.132	64	0.645	-29
		800	0.496	-49	2.21	68	0.164	57	0.612	-33
		1000	0.499	-54	1.83	58	0.198	51	0.592	-42
	10	200	0.643	-25	7.37	114	0.051	71	0.668	-18
		400	0.542	-27	4.28	90	0.094	69	0.060	-25
		600	0.466	-34	3.10	76	0.132	65	0.603	-28
		800	0.465	-46	2.49	66	0.166	59	0.577	-31
		1000	0.476	-51	2.05	57	0.202	53	0.557	-40
	20	200	0.57	-23	8.44	109	0.049	73	0.621	-18
		400	0.496	-24	4.73	88	0.093	71	0.562	-24
		600	0.427	-31	3.38	75	0.131	67	0.572	-27
		800	0.427	-43	2.69	66	0.165	60	0.551	-30
		1000	0.445	-47	2.21	57	0.203	54	0.532	-38

7

MRF534 COMMON-EMITTER S-PARAMETERS

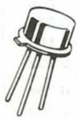
V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	$\angle\phi$	$\|S_{21}\|$	$\angle\phi$	$\|S_{12}\|$	$\angle\phi$	$\|S_{22}\|$	$\angle\phi$
5.0	5.0	200	0.734	-22	3.70	126	0.066	66	0.507	-39
		400	0.580	-28	2.56	108	0.116	65	0.409	-48
		600	0.444	-37	2.09	95	0.158	62	0.403	-52
		800	0.400	-47	1.80	86	0.195	56	0.364	-56
		1000	0.366	-47	1.55	79	0.234	51	0.348	-69
	10	200	0.645	-27	5.36	124	0.058	69	0.394	-43
		400	0.503	-33	3.44	106	0.109	71	0.316	-52
		600	0.376	-43	2.68	93	0.153	69	0.323	-52
		800	0.333	-54	2.24	84	0.192	65	0.290	-55
		1000	0.295	-54	1.91	77	0.233	61	0.276	-71
	20	200	0.586	-28	5.90	122	0.053	70	0.338	-52
		400	0.454	-34	3.73	105	0.099	73	0.259	-60
		600	0.329	-46	2.87	93	0.143	72	0.267	-58
		800	0.289	-59	2.38	85	0.181	68	0.240	-59
		1000	0.248	-58	2.04	77	0.221	65	0.235	-75
10	5.0	200	0.752	-21	4.28	125	0.066	70	0.550	-28
		400	0.624	-26	2.77	107	0.123	68	0.495	-38
		600	0.512	-34	2.19	94	0.168	65	0.503	-44
		800	0.476	-44	1.86	86	0.207	60	0.464	-51
		1000	0.447	-45	1.60	79	0.246	55	0.443	-64
	10	200	0.685	-24	5.47	123	0.060	71	0.442	-33
		400	0.553	-28	3.46	105	0.113	71	0.385	-42
		600	0.433	-37	2.68	93	0.156	68	0.397	-46
		800	0.391	-49	2.25	85	0.194	63	0.362	-51
		1000	0.359	-47	1.92	78	0.233	59	0.342	-65
	20	200	0.621	-26	6.38	121	0.055	71	0.372	-40
		400	0.488	-31	3.97	104	0.103	72	0.316	-48
		600	0.365	-41	3.04	93	0.145	70	0.332	-50
		800	0.323	-52	2.51	85	0.182	66	0.301	-54
		1000	0.290	-50	2.13	79	0.219	63	0.288	-68

MRF536 COMMON-EMITTER S-PARAMETERS

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	$\angle\phi$	$\|S_{21}\|$	$\angle\phi$	$\|S_{12}\|$	$\angle\phi$	$\|S_{22}\|$	$\angle\phi$
5.0	5.0	400	0.401	-74	5.38	108	0.09	54	0.49	-48
		800	0.181	-102	3.03	86	0.138	51	0.35	-64
		1200	0.136	-157	2.13	70	0.181	48	0.32	-70
		1600	0.151	175	1.68	59	0.21	45	0.27	-80
		2000	0.16	148	1.44	52	0.24	41	0.269	-100
	10	400	0.289	-94	6.58	103	0.076	56	0.379	-56
		800	0.14	-137	3.55	84	0.122	55	0.266	-73
		1200	0.174	169	2.46	70	0.165	53	0.238	-77
		1600	0.196	154	1.93	60	0.196	50	0.198	-87
		2000	0.227	130	1.65	51	0.230	46	0.202	-110
	20	400	0.233	-118	7.28	99	0.066	60	0.296	-65
		800	0.163	-169	3.88	82	0.110	59	0.204	-84
		1200	0.233	156	2.65	69	0.153	57	0.179	-84
		1600	0.253	144	2.06	59	0.186	55	0.143	-96
		2000	0.290	123	1.75	50	0.220	51	0.160	-121
10	5.0	400	0.478	-54	5.14	109	0.086	58	0.535	-39
		800	0.279	-66	2.90	88	0.141	53	0.420	-55
		1200	0.166	-97	2.08	73	0.184	48	0.388	-62
		1600	0.151	-123	1.67	64	0.209	44	0.33	-72
		2000	0.110	-158	1.44	55	0.243	39	0.313	-90
	10	400	0.356	-67	6.59	105	0.075	59	0.418	-47
		800	0.182	-84	3.59	86	0.124	56	0.311	-62
		1200	0.119	-141	2.53	73	0.166	52	0.284	-67
		1600	0.131	-166	2.00	62	0.193	49	0.230	-76
		2000	0.135	154	1.72	55	0.226	45	0.222	-98
	20	400	0.26	-85	7.66	101	0.066	61	0.328	-53
		800	0.124	122	4.09	84	0.111	59	0.236	-69
		1200	0.148	172	2.83	72	0.152	56	0.216	-71
		1600	0.172	158	2.22	62	0.182	54	0.172	-80
		2000	0.201	130	1.88	54	0.214	50	0.171	-104

MM8000
MM8001
MM8002

CASE 79-02, STYLE 1
TO-39 (TO-205AD)



HIGH FREQUENCY TRANSISTOR

NPN SILICON

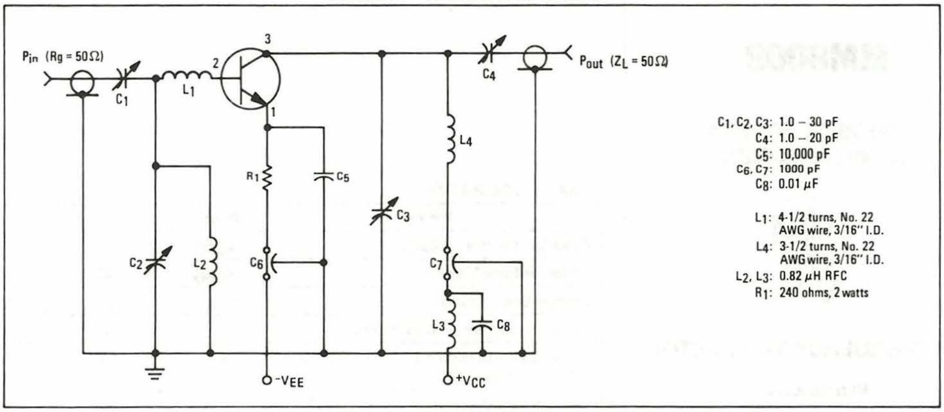
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current	I_C	0.4	Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	3.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage ($I_C = 5.0$ mAdc, $I_B = 0$)		$V_{CEO(sus)}$	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)		$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)		$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 28$ Vdc, $I_B = 0$)		I_{CEO}	—	—	20	μAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = 50$ mAdc, $V_{CE} = 15$ Vdc)		h_{FE}	30	—	—	—
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product		f_T				MHz
($I_C = 25$ mAdc, $V_{CE} = 15$ Vdc, f = 200 MHz)	MM8000		550	—	—	
	MM8001		700	—	—	
	MM8002		1000	—	—	
($I_C = 50$ mAdc, $V_{CE} = 15$ Vdc, f = 200 MHz)	MM8000		700	—	—	
	MM8001		900	—	—	
	MM8002		1200	—	—	
($I_C = 100$ mAdc, $V_{CE} = 15$ Vdc, f = 200 MHz)	MM8000		700	—	—	
	MM8001		900	—	—	
	MM8002		1000	—	—	
Output Capacitance ($V_{CB} = 30$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{obo}	—	—	3.5	pF
Noise Figure (Figure 1) ($I_C = 10$ mAdc, $V_{CE} = 15$ Vdc, f = 200 MHz)		NF	—	2.7	—	dB
FUNCTIONAL TEST						
Common-Emitter Amplifier Power Gain (Figure 1) ($I_C = 10$ mAdc, $V_{CE} = 15$ Vdc, f = 200 MHz)		G_{pe}	—	11.4	—	dB

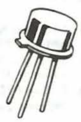
FIGURE 1 — 200 MHz TEST CIRCUIT



7

MM8009

CASE 79-02, STYLE 1
TO-39 (TO-205AD)



HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Collector-Base Voltage	V_{CBO}	45	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	400	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

7

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	45	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	I_{CEO}	—	—	100	μAdc
Collector Cutoff Current (V_{CE} = 35 Vdc, V_{BE} = 0)	I_{CES}	—	—	10	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	20	—	—	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	f_T	1000	—	—	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	2.3	3.0	pF
FUNCTIONAL TEST					
Power Output (Figure 1) (P_{in} = 316 mW, V_{CE} = 28 Vdc, f = 1.0 GHz)	P_{out}	0.9	—	—	Watt
Power Output (Oscillator) (Figure 2) (V_{CE} = 20 Vdc, V_{EB} = 1.5 Vdc, f = 1.68 GHz) (Minimum Efficiency = 15%)	P_{out}	—	0.3	—	Watt
Collector Efficiency (P_{in} = 316 mW, V_{CE} = 28 Vdc, f = 1.0 GHz)	η	35	—	—	%

FIGURE 1 – 1.0 GHz POWER AMPLIFIER TEST CIRCUIT

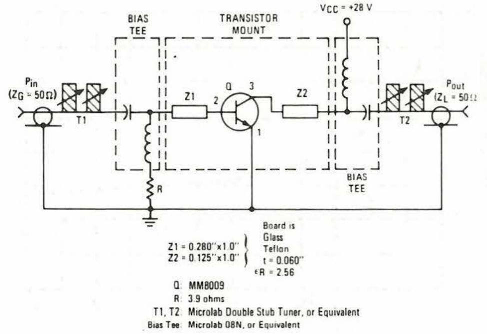


FIGURE 2 – 1.68 GHz POWER OSCILLATOR TEST CIRCUIT

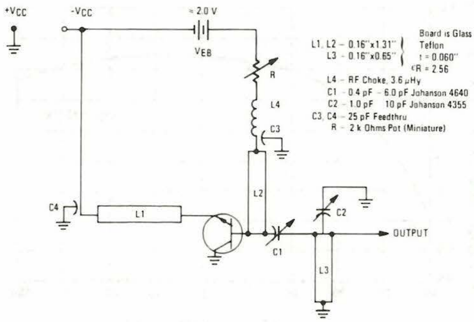


FIGURE 3 – POWER OUTPUT versus POWER INPUT

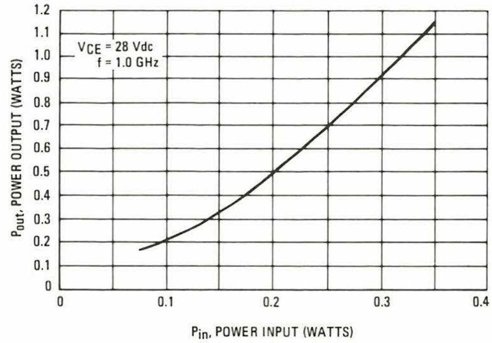


FIGURE 4 – POWER OUTPUT versus FREQUENCY

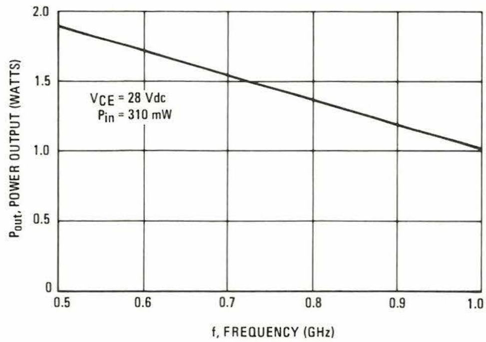


FIGURE 5 – POWER OUTPUT versus VOLTAGE

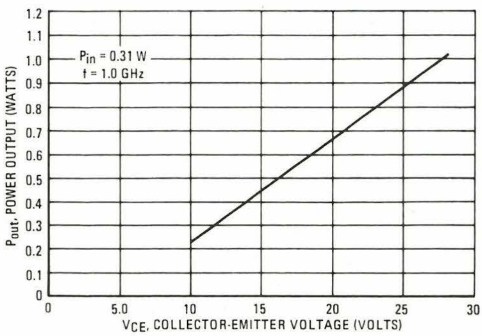
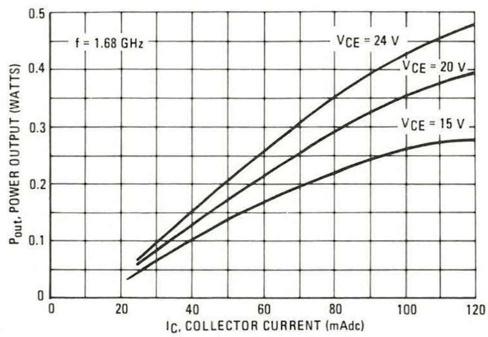


FIGURE 6 – OSCILLATOR POWER OUTPUT versus CURRENT



7

FIGURE 7 – CURRENT-GAIN–BANDWIDTH PRODUCT

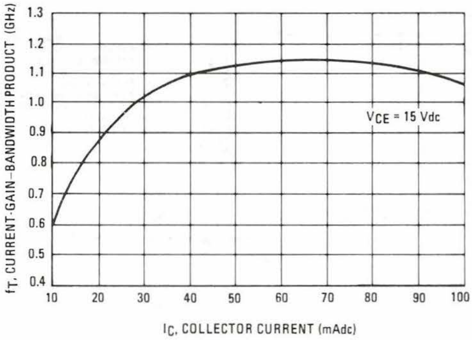
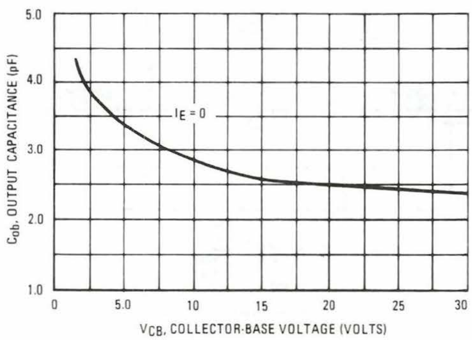


FIGURE 8 – OUTPUT CAPACITANCE versus VOLTAGE



7

MRF207

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	0.4	Adc
Total Device Dissipation @ T_C = 25°C(1) Derate above 25°C	P_D	3.5 20	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

(1) This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.

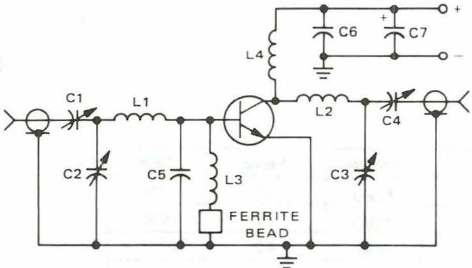
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	18	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 2.0 mAdc, I_E = 0)	$V_{(BR)CBO}$	36	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	—	—	—
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 1.0 W, f = 220 MHz)	G_{PE}	8.2	12.5	—	dB
Input Impedance (P_{out} = 1.0 W, f = 220 MHz)	Z_{in}	—	10−j11.5	—	Ohms
Output Impedance (P_{out} = 1.0 W, f = 220 MHz)	Z_{out}	—	32−j41	—	Ohms

7

220 MHz TEST CIRCUIT

FIGURE 1 – MRF207

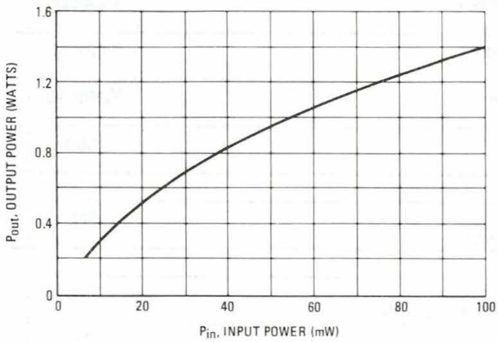


C1	2.0 - 50 pF	ARCO 461
C2, C4	5.0 - 80 pF	ARCO 462
C3	1.5 - 15 pF	ARCO 460
C5	40 pF	
C6	1000 pF	
C7	5.0 μF	TANTALUM
L1	1 Turn, #20 AWG, 1/4" ID	
L2	4 Turns, #20 AWG, 1/4 ID	
L3, L4	15 μH RFC	

OUTPUT POWER versus INPUT POWER

(V_{CC} = 12.5 Vdc, f = 220 MHz)

FIGURE 2 — MRF207



7

MRF225

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	0.25	Adc
Total Device Dissipation @ T_C = 25°C(1) Derate above 25°C	P_D	3.5 0.02	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

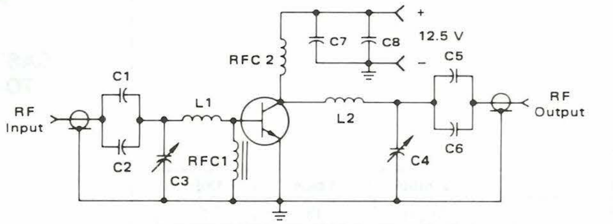
(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as Class C RF amplifiers.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 20 mAdc, I_B = 0)	$V_{(BR)CEO}$	18	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 20 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	100	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	15	150	—
SMALL SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 12 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	8.0	pF
FUNCTIONAL TEST (FIGURE 1)				
Common-Emitter Amplifier Power Gain (P_{out} = 1.5 W, V_{CC} = 12.5 Vdc, f = 225 MHz)	G_{PE}	9.0	—	dB
Collector Efficiency (P_{out} = 1.5 W, V_{CC} = 12.5 Vdc, f = 225 MHz)	η	50	—	%

7

FIGURE 1 – 225 MHz TEST CIRCUIT SCHEMATIC



C1,2,5	50 pF Dipped Mica
C3	1.5-20 pF ARCO 402
C4	4.0-40 pF ARCO 403
C6	100 pF Dipped Mica
C7	1000 pF UNELCO
C8	1.0 μF 35 V Tantalum
L1	0.6 Inch #18 AWG
L2	2 Turns x 0.25 inch ID #18 AWG
RFC 1	Ferroxcube VK200
RFC 2	2.2 μH Molded Choke

FIGURE 2 – OUTPUT POWER versus INPUT POWER

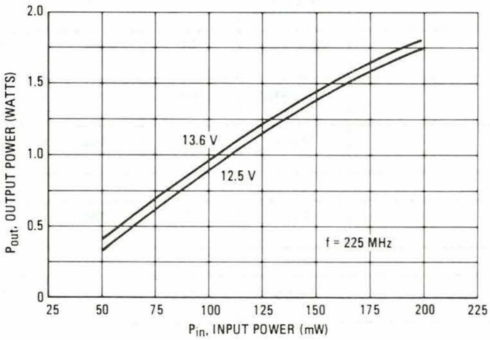
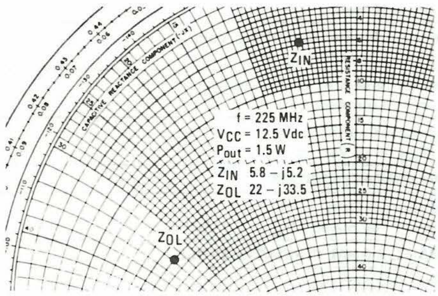


FIGURE 3 – SERIES EQUIVALENT IMPEDANCE



MRF227

CASE 79-03, STYLE 5

HIGH FREQUENCY TRANSISTOR

NPN SILICON

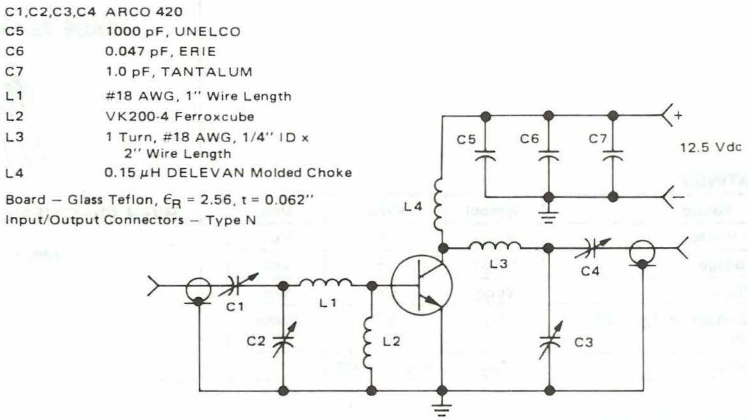
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	16	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	400	mdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.5	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	$V_{(BR)CEO}$	16	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	1.0	mAdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 55°C)	I_{CES}	—	—	10	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	20	—	200	—
SMALL SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	—	15	pF
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain (P_{out} = 3.0 W, V_{CC} = 12.5 Vdc, f = 225 MHz)	G_{PE}	13.5	15	—	dB
Collector Efficiency (P_{out} = 3.0 W, V_{CC} = 12.5 Vdc, f = 225 MHz)	η	60	—	—	%

FIGURE 1 – 225 MHz TEST CIRCUIT



7

FIGURE 2 – INPUT POWER versus OUTPUT POWER – 12.5 V

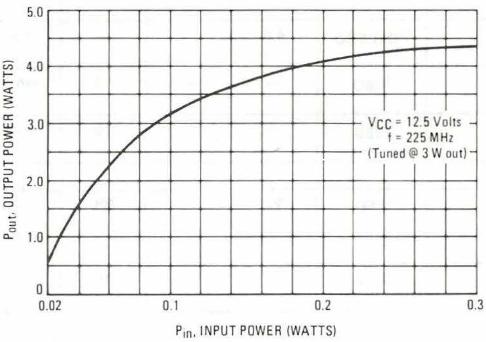


FIGURE 3 – INPUT POWER versus OUTPUT POWER – 13.6 V

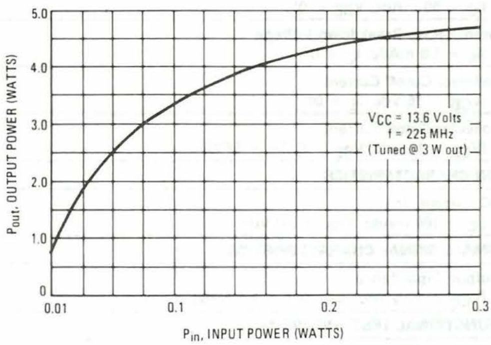


FIGURE 4 – INPUT POWER versus OUTPUT POWER – 7.5 V

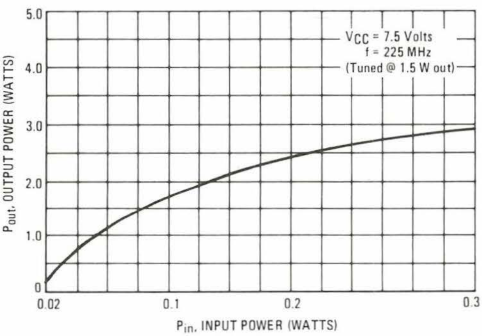


FIGURE 5 – OUTPUT POWER versus SUPPLY VOLTAGE

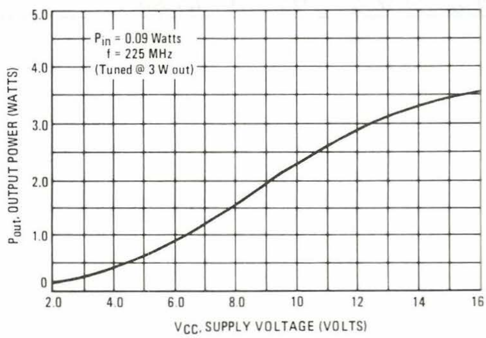
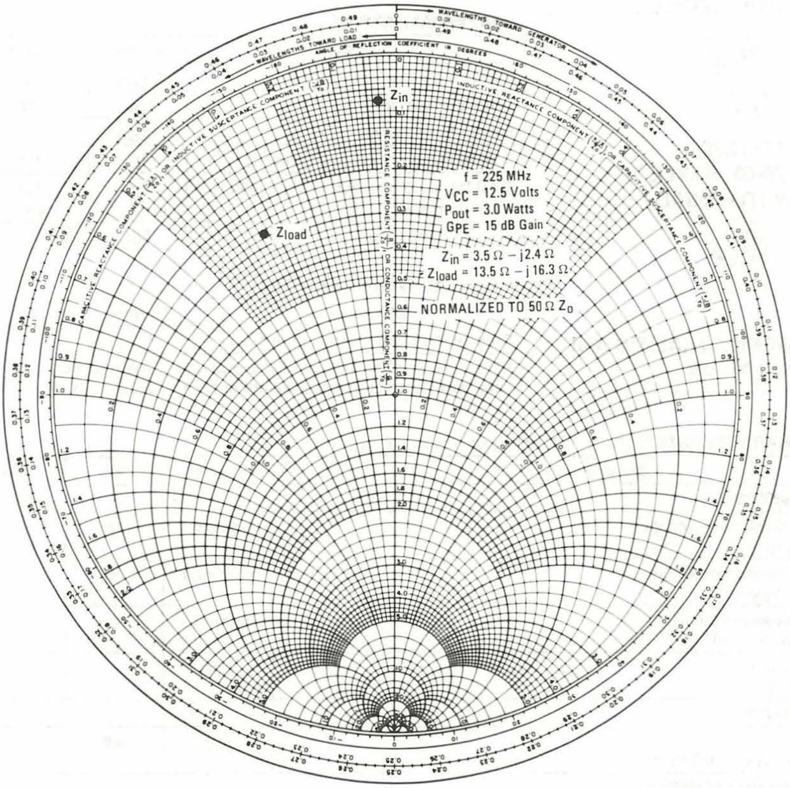


FIGURE 6 — SERIES EQUIVALENT IMPEDANCE



MRF229
MRF230

MRF229
CASE 79-03, STYLE 5

MRF230
CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	0.5	Adc
Total Device Dissipation @ T_C = 25°C(1) Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

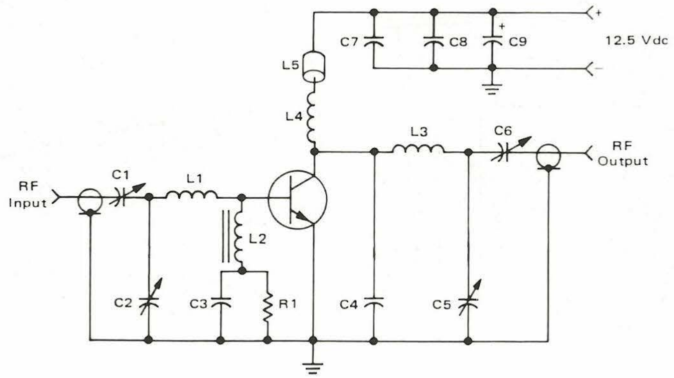
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as Class C RF Amplifiers.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 25 mAdc, I_B = 0)	$V_{(BR)CEO}$	18	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 25 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.25 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	0.5	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	—	—
SMALL SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	25	pF
FUNCTIONAL TEST (FIGURE 1)				
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 1.5 W, f = 90 MHz)	G_{PE}	10	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 1.5 W, f = 90 MHz)	η	55	—	%
Load Mismatch (V_{CC} = 12.5 Vdc, P_{out} = 1.5 W, f = 90 MHz, $T_C \leq$ 25°C)	—	VSWR > 30:1 Through All Phase Angles in 3 Second Interval After Which Devices Will Meet G_{PE} Test Limits		

FIGURE 1 – 90 MHz TEST CIRCUIT SCHEMATIC



C1	5.0-80 pF, ARCO 462	C9	20 µF, 15 Vdc TANTALUM
C2,C6	25-280 pF, ARCO 464	L1	2 Turns, #18 AWG, 3/8" I.D. 3/8" Long
C3	250 pF UNELCO	L2	2.5 Turns, #20 AWG, on Ferrite Bead. FERROXCUBE 56-590-65-3B
C4	10 pF UNELCO	L3	3 Turns, #18 AWG, 3/8" I.D., 1/2" Long
C5	9.0-180 pF, ARCO 463	L4	0.68 µH, 9230-16 MILLER Molded Choke
C7	1000 pF UNELCO	L5	Ferrite Bead, FERROXCUBE 56-590-65-3B
C8	0.47 µF ERIE Disc Ceramic	R1	4.7 OHM, 1/2 W, 10% Carbon

Input/Output Connectors – Type BNC

7

FIGURE 2 – OUTPUT POWER versus INPUT POWER

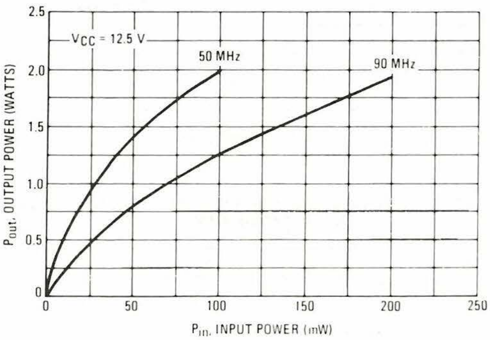


FIGURE 3 – OUTPUT POWER versus FREQUENCY

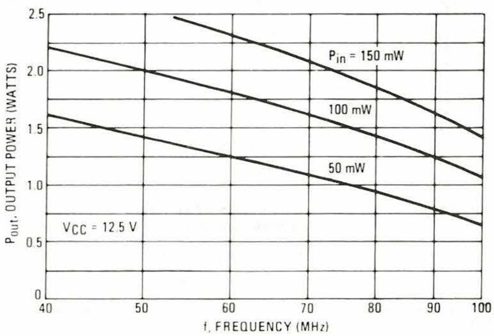


FIGURE 4 – OUTPUT POWER versus SUPPLY VOLTAGE

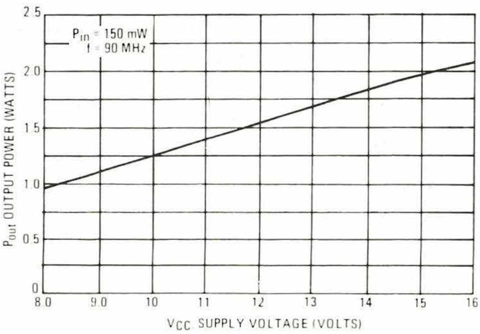
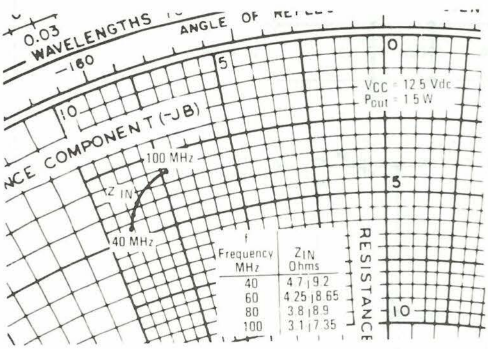


FIGURE 5

SERIES EQUIVALENT INPUT IMPEDANCE



SERIES EQUIVALENT OUTPUT IMPEDANCE

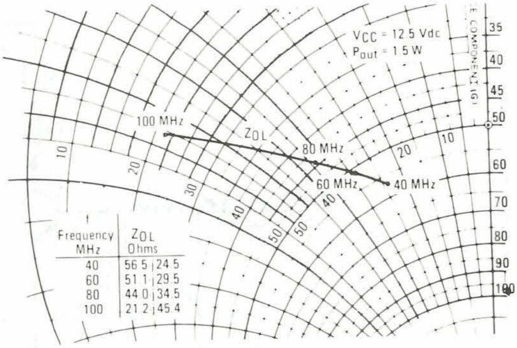


FIGURE 6 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

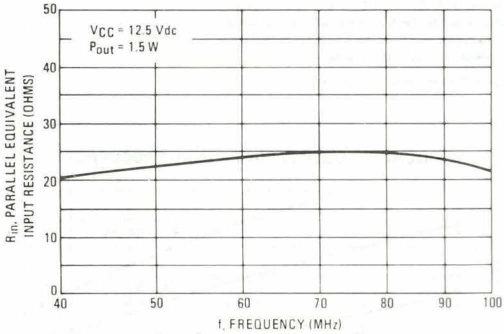
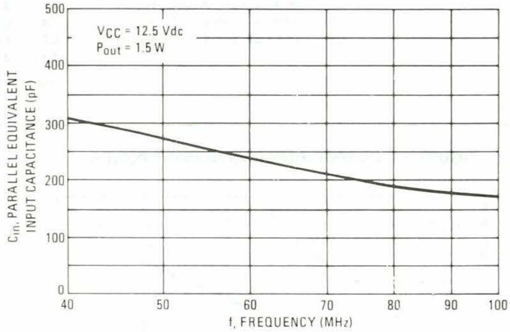


FIGURE 7 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY



7

FIGURE 8 – PARALLEL EQUIVALENT OUTPUT RESISTANCE versus FREQUENCY

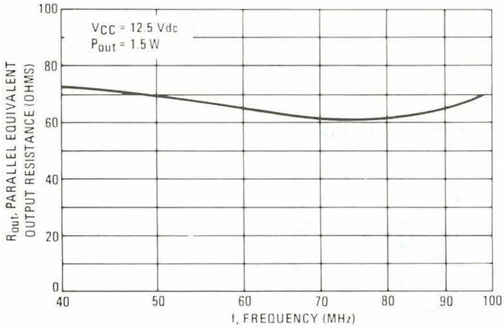
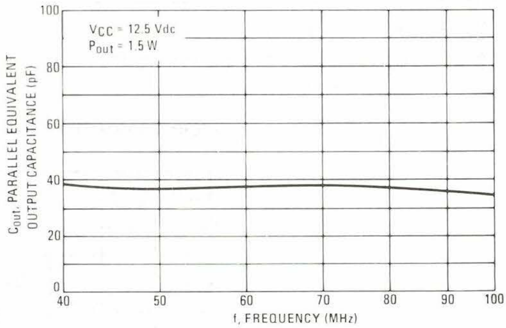


FIGURE 9 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY



MRF237

CASE 79-03, STYLE 5

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	640	mAdc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	8.0 45.7	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

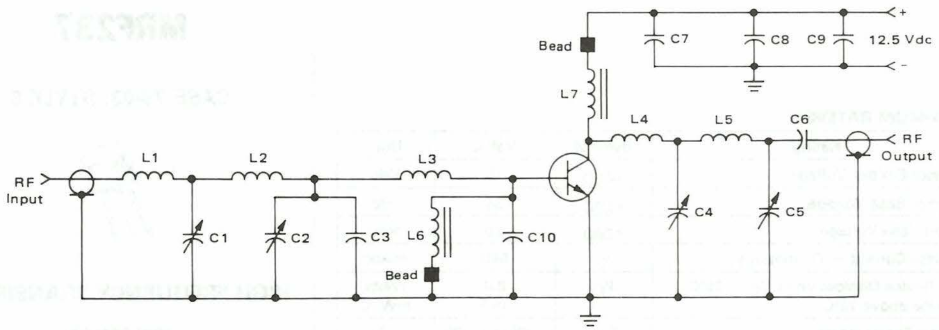
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	20	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	18	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 5.0$ mAdc, $V_{BE} = 0$)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 1.0$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	—	0.25	mAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 250$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	5.0	—	—	—
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance ($V_{CB} = 15$ Vdc, $I_E = 0$, f = 0.1 MHz)	C_{obo}	—	15	20	pF
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain ($P_{out} = 4.0$ W, $V_{CC} = 12.5$ Vdc, $I_C(max) = 640$ mAdc, f = 175 MHz)	G_{PE}	12	14	—	dB
Collector Efficiency ($P_{out} = 4.0$ W, $V_{CC} = 12.5$ Vdc, $I_C(max) = 640$ mAdc, f = 175 MHz)	η	50	62	—	%

FIGURE 1 — 175 MHz TEST CIRCUIT SCHEMATIC



C1,C4,C5	3.0 - 180 pF, ARCO 463	L1	1/2 Turn, #16 AWG, 0.5" I.D.
C2	1.75 - 30 pF, ARCO 461	L2	1", #16 AWG
C3	40 pF, UNELCO	L3	0.75" #16 AWG
C6	0.01 μF, ERIE	L4,L5	1 Turn, #16 AWG, 0.5" I.D.
C7	0.1 μF, ERIE REDCAP	L6	0.15 μH Molded Choke
C8	1.0 μF, TANTALUM	L7	1.2 μH Molded Choke
C9	1000 pF, UNELCO	Beads	FERRITE Beads, FERROXCUBE
C10	100 pF UNELCO		#56-570-65/3B

FIGURE 2 — OUTPUT POWER versus INPUT POWER

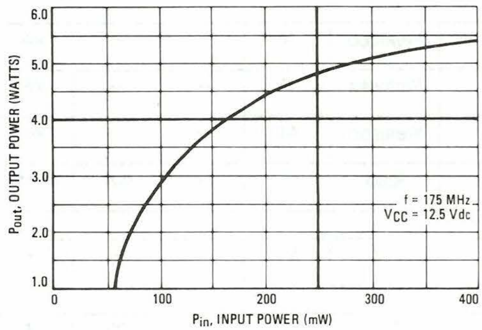


FIGURE 3 — OUTPUT POWER versus FREQUENCY

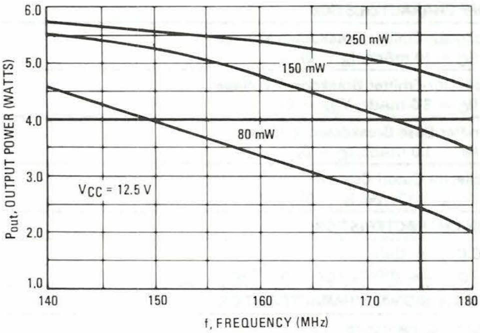


FIGURE 4 — OUTPUT POWER versus SUPPLY VOLTAGE

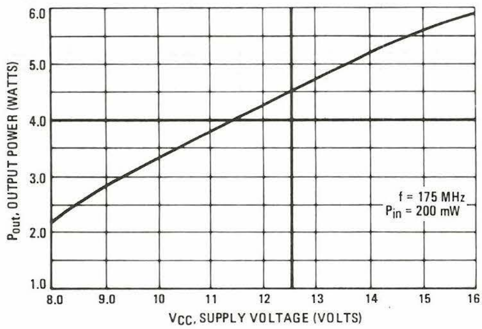
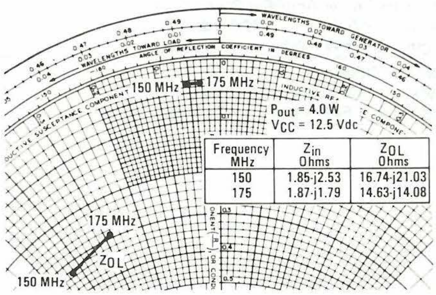


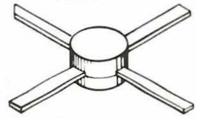
FIGURE 5 — SERIES EQUIVALENT IMPEDANCE



7

MRF313
MRF313A

MRF313
CASE 305A-01, STYLE 1



MRF313A
CASE 305-1, STYLE 1

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	150	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 35	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

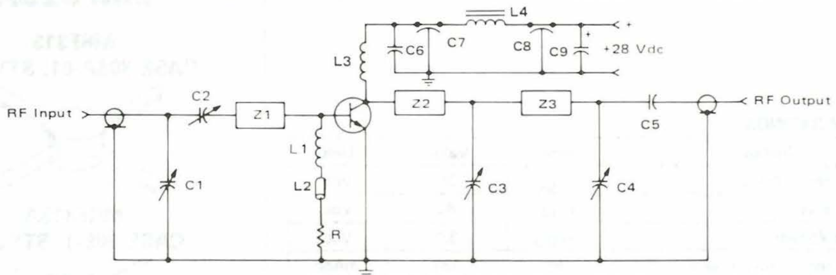
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	28.5	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	35	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	35	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, I_B = 0)	I_{CEO}	—	—	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	60	150	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 20 Vdc, f = 200 MHz)	f_T	—	2.5	—	GHz
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	3.5	5.0	pF
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain(1) (V_{CC} = 28 Vdc, P_{out} = 1.0 W, f = 400 MHz)	G_{pe}	15	16	—	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 1.0 W, f = 400 MHz)	η	—	45	—	%
Series Equivalent Input Impedance (V_{CC} = 28 Vdc, P_{out} = 1.0 W, f = 400 MHz)	Z_{in}	—	6.4 − j4.8	—	Ohms
Series Equivalent Output Impedance (V_{CC} = 28 Vdc, P_{out} = 1.0 W, f = 400 MHz)	Z_{out}	—	75 − j45	—	Ohms

(1) Class C

FIGURE 1 — 400 MHz POWER GAIN TEST CIRCUIT

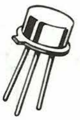


C1,C2,C4	1.0-20 pF JOHANSON 9063	L1,L3	5 Turns, AWG #20, ¼" I.D.		
C3	1.0-10 pF JOHANSON	L2	Ferrite Bead, FERROXCUBE No. 56-590-65/4B	R	4.7 Ohms, ¼ W
C5	150 pF Chip			Z1	2.0" x 0.1" MICROSTRIP LINE
C6	0.1 µF	L4	FERROXCUBE VK200-20/4B	Z2,Z3	2.6" x 0.1" MICROSTRIP LINE
C7,C8	680 pF Feedthru		Input/Output Connectors — Type N		
C9	1.0 µF TANTALUM		Board — Glass Teflon, ϵ = 2.56, t = 0.062"		

7

MRF402

CASE 79-02, STYLE 1
TO-39 (TO-205AD)



HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

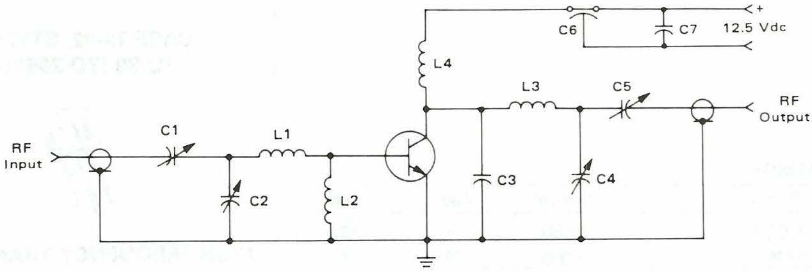
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	0.5	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.62	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	$V_{(BR)CEO}$	18	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.25 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	0.5	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	—	—
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	25	pF
FUNCTIONAL TEST (FIGURE 1)				
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 1.0 W, $I_C(max)$ = 160 mAdc, f = 50 MHz)	G_{PE}	10	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 1.0 W, $I_C(max)$ = 160 mAdc, f = 50 MHz)	η	50	—	%

7

FIGURE 1 – 50 MHz TEST CIRCUIT SCHEMATIC



C1,C2,C5 – 25-280 pF, ARCO 464 or equiv.
C3 – 40 pF, 500 Vdc UNELCO
C4 – 9.0-180 pF ARCO 463 or equiv.
C6 – 1000 pF feedthru
C7 – 0.1 μF, 75 Vdc

L1 – 2 Turns No. 18 AWG, 3/8" I.D.
L2 – 2 1/2 Turns, Small Ferrite Bead
L3 – 5 Turns No. 18 AWG, 3/8" I.D.
L4 – 1.0 μH RF Choke

7

MRF501
MRF502

CASE 20-03, STYLE 10
TO-72 (TO-206AF)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

Refer to 2N5179 for curves

MAXIMUM RATINGS

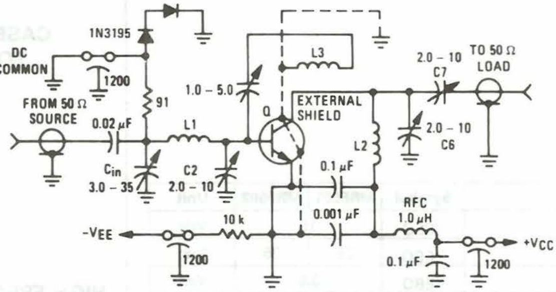
Rating	Symbol	MRF501	MRF502	Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CBO}	25	35	Vdc
Emitter-Base Voltage	V_{EBO}	3.5		Vdc
Collector Current	I_C	50		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14		mW mW/°C
Storage Temperature	T_{stg}	−65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 3.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	MRF501 MRF502	$V_{(BR)CBO}$	25 35	— —	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 μAdc, I_C = 0)		$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 1.0 Vdc, I_E = 0)	MRF501 MRF502	I_{CBO}	— —	— —	50 20	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc)	MRF501 MRF502	h_{FE}	30 40	— —	250 170	—
SMALL SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 100 MHz)	MRF501 MRF502	f_T	600 800	1000 2000	— —	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)		C_{cb}	—	0.6	—	pF
Collector Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 6.0 Vdc, f = 31.8 MHz)		$r_b'C_c$	—	8.0	—	ps
Noise Figure (Figure 1) (I_C = 1.5 mAdc, V_{CE} = 6.0 Vdc, R_S = 50 ohms, f = 200 MHz)	MRF501 MRF502	NF	— —	4.5 4.0	— —	dB
FUNCTIONAL TEST						
Common-Emitter Amplifier Power Gain (Figure 1) (V_{CC} = 6.0 Vdc, I_C = 5.0 mAdc, f = 200 MHz)	MRF501 MRF502	G_{pe}	— —	15 17	— —	dB

7

FIGURE 1 — 200 MHz AMPLIFIER POWER GAIN AND NOISE FIGURE CIRCUIT

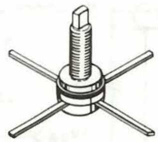


L1 1 3/4 Turns, #18 AWG, 0.5" Long, 0.5" Diameter
L2 2 Turns, #16 AWG, 0.5" Long, 0.5" Diameter
L3 2 Turns, #18 AWG, 0.25" Long, 0.5" Diameter, Position Approximately 0.25" from L2

7

MRF511

CASE 244A-01, STYLE 1
TO-117



HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

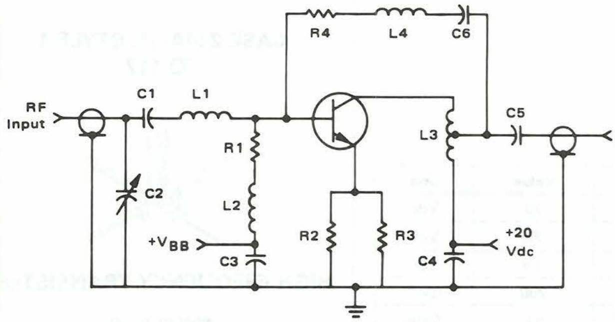
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	35	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	250	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C
Stud Torque(1)	—	6.5	In. Lb.

(1) For Repeated Assembly use 5 In. Lb.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	35	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	I_{CEO}	—	—	100	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 80 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	50	200	—
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	—	0.2	0.5	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 80 mAdc, V_{CE} = 20 Vdc, f = 200 MHz)	f_T	1.5	2.1	—	GHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	3.2	4.5	pF
Noise Figure (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 200 MHz)	NF	—	7.3	10	dB
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain (V_{CE} = 20 Vdc, I_C = 80 mAdc, f = 250 MHz)	G_{pe}	10	11	—	dB
2nd Order Intermodulation Distortion (V_{CE} = 20 Vdc, I_C = 80 mAdc, V_{out} = +50 dBmV, Chn 2 + Chn 13 = 266.5 MHz)	IMD	—	−55	−50	dB
Cross-Modulation Distortion (V_{CE} = 20 Vdc, V_{out} = +50 dBmV, I_C = 80 mAdc) Chn 13 Chn R	 12 Chn XMD 30 Chn XMD	 — —	 −59 −46	 −57 —	dB
Triple Beat (V_{CE} = 20 Vdc, I_C = 80 mAdc, V_{out} = +50 dBmV, Chn 2 + Chn 3 + Chn E = 261.75 MHz)	TB	—	−68	−65	dB

FIGURE 1 – 40 to 330 MHz BROADBAND TEST CIRCUIT SCHEMATIC



CIRCUIT PERFORMANCE	Min	Typ
Input/Output Return Loss	–	18 dB
Flatness	–	±0.3 dB
Gain	10 dB	
Bandwidth	–	40-300 MHz

C1,C3,C4,C5,C6	0.002 μF Ceramic Disc
C2	0.35-3.5 pF JOHANSON 4702
L1	2 Turns, #20 AWG, 1/8" I.D., 0.2" Long
L2	5 μH, Ferrite Choke, MILLER
L3	18 Turns, #24 AWG Enamelled, on Ferrite Torrid Core FERROXCUBE 1041T060-4C7
L4	5 Turns, #20 AWG, 3/16" I.D., 0.35" Long
R1	4.7 kΩ, 1/4W, 10%
R2	27 Ω, 1W, 10%
R3	27 Ω, 1W, 10%
R4	300 Ω, 1/4W, 10%.

Input/Output Connectors – Type F

Z_o – 75 Ohms

FIGURE 2 – CURRENT-GAIN-BANDWIDTH PRODUCT

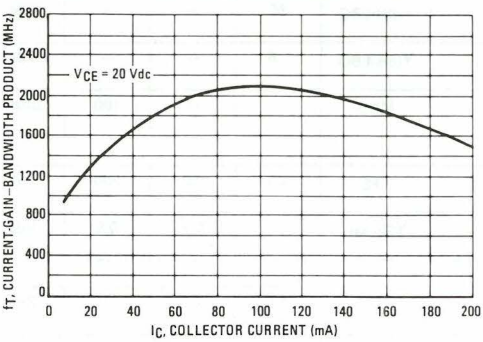


FIGURE 3 – OUTPUT CAPACITANCE

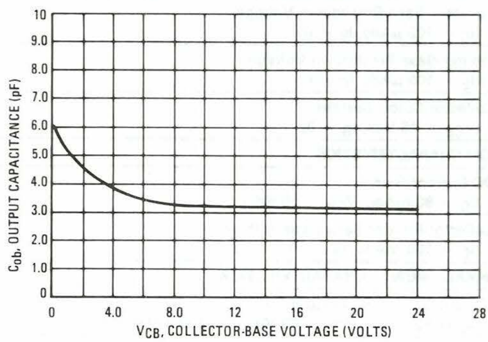


FIGURE 4 – INPUT CAPACITANCE

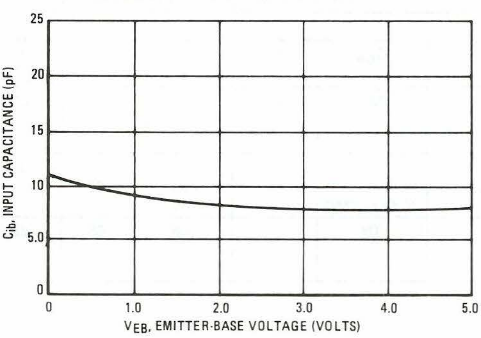


FIGURE 5 – BROADBAND NOISE FIGURE

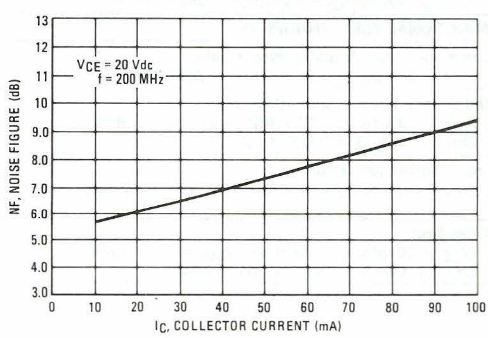


FIGURE 6 – 12 CHANNEL CROSS-MODULATION versus COLLECTOR-EMITTER VOLTAGE

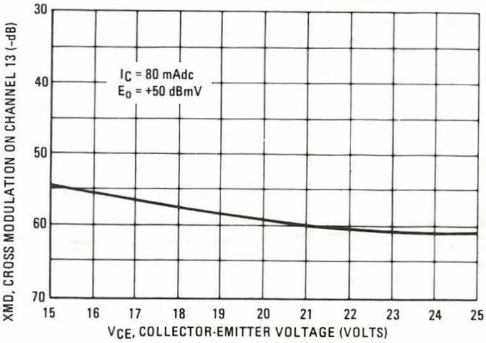


FIGURE 7 – 12 CHANNEL CROSS-MODULATION versus COLLECTOR CURRENT

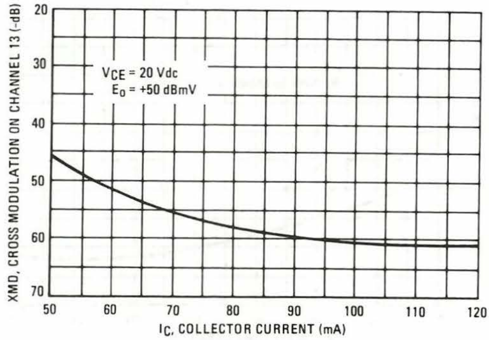


FIGURE 8 – 30 CHANNEL CROSS-MODULATION ON CHANNEL R

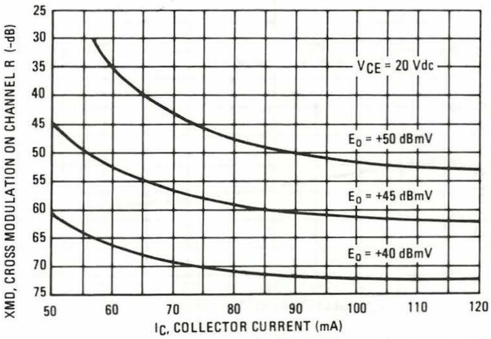


FIGURE 9 – 30 CHANNEL CROSS-MODULATION ON CHANNEL 2,13,R

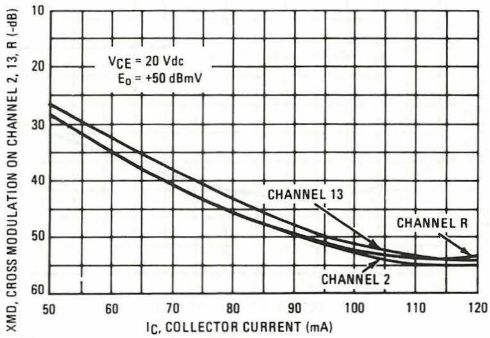
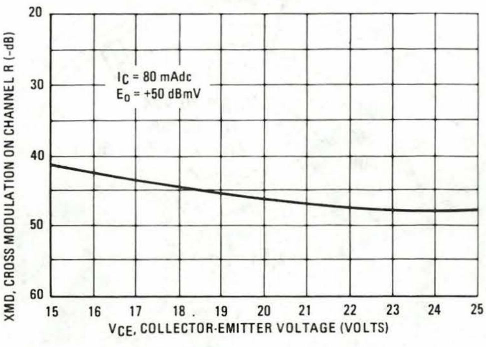


FIGURE 10 – 30-CHANNEL CROSS-MODULATION versus COLLECTOR-EMITTER VOLTAGE



7

FIGURE 11 – TRIPLE BEAT versus COLLECTOR CURRENT

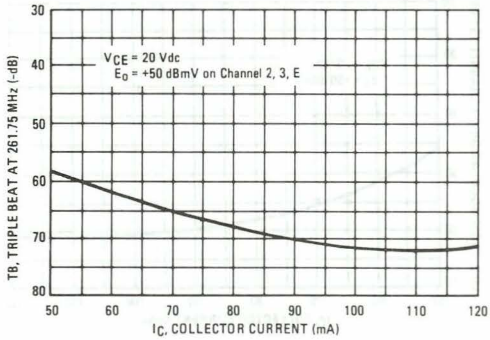


FIGURE 12 – TRIPLE BEAT versus COLLECTOR-EMITTER VOLTAGE

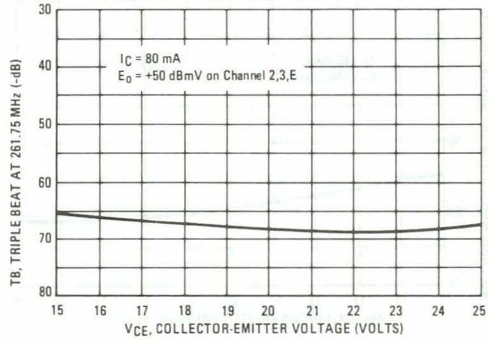


FIGURE 13 – SECOND ORDER IMD versus COLLECTOR CURRENT

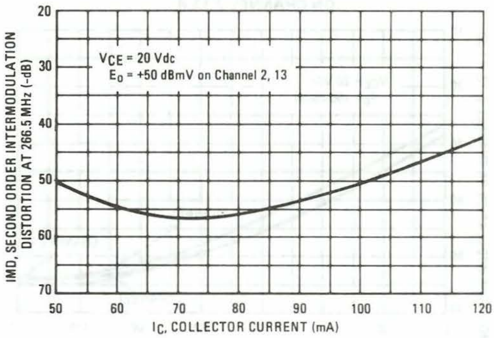


FIGURE 14 – SECOND ORDER IMD versus COLLECTOR-EMITTER VOLTAGE

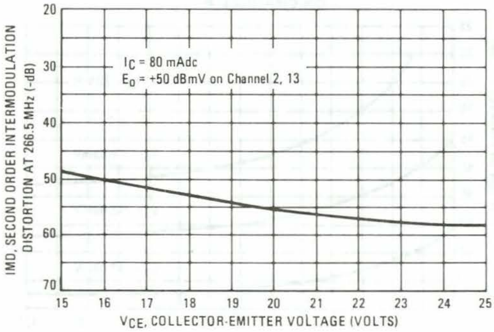


FIGURE 15 – INPUT REFLECTION COEFFICIENT (S11) AND OUTPUT REFLECTION COEFFICIENT (S22) versus FREQUENCY

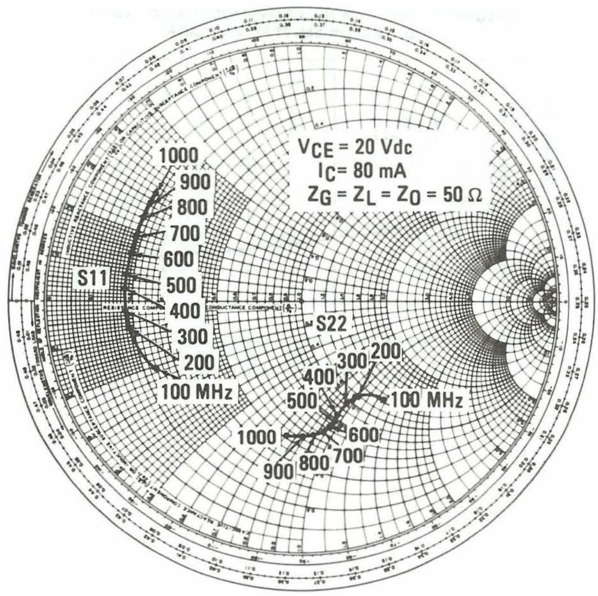


FIGURE 16 – FORWARD TRANSMISSION COEFFICIENT (S21) versus FREQUENCY

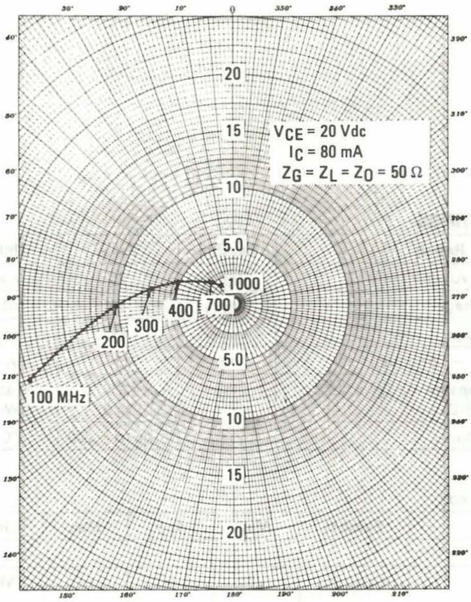
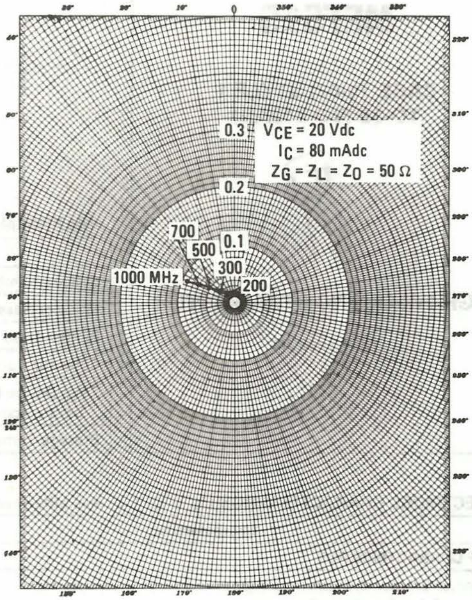


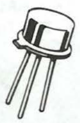
FIGURE 17 – REVERSE TRANSMISSION COEFFICIENT (S12) versus FREQUENCY



7

MRF515

CASE 79-02, STYLE 1
TO-39 (TO-205AD)



HIGH FREQUENCY TRANSISTOR

NPN SILICON

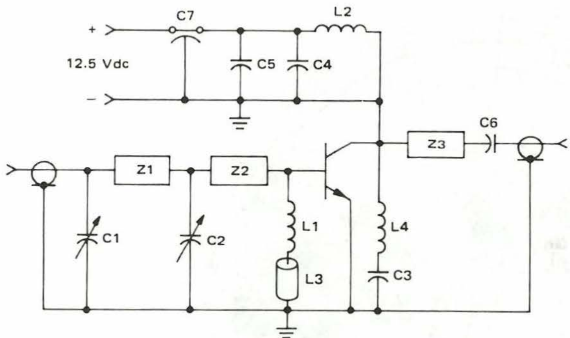
MAXIMUM RATINGS

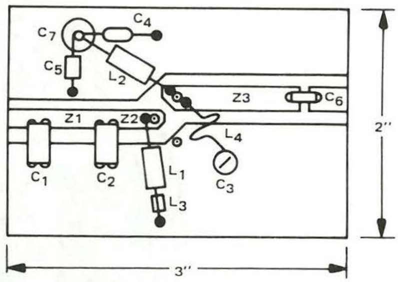
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Colector-Base Voltage	V_{CBO}	35	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	150	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 14.3	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	35	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	I_{CEO}	—	—	10	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	60	150	—
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	—	—	0.5	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 200 MHz)	f_T	1800	2000	—	MHz
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	3.5	4.0	pF
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 0.75 W, f = 470 MHz)	G_{PE}	8.0	8.5	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 0.75 W, f = 470 MHz)	η	50	70	—	%
Series Equivalent Input Impedance (V_{CC} = 12.5 Vdc, P_{out} = 0.75 W, f = 470 MHz)	Z_{in}	—	14+j4.0	—	Ohms
Series Equivalent Output Impedance (V_{CC} = 12.5 Vdc, P_{out} = 0.75 W, f = 470 MHz)	Z_{out}	—	28−j38	—	Ohms

FIGURE 1 — 470 MHz TEST CIRCUIT





C1,C2,C3 - 1.0-10 pF JOHANSON
C4 - 0.1 μF disc
C5 - 1.0 μF TANTULAM
C6 - 0.018 μF chip
C7 - 1000 pF Feedthru
L1,L2 - 0.15 μF Choke
L3 - Bead Ferrite
Z1,Z2 - 0.09″ x 0.5″ LINE, Z_o = 100 Ω
Z3 - 0.18″ x 1.0″ LINE, Z_o = 50 Ω

BOARD = 0.032″ TEFLON GLASS, $\epsilon_R = 2.5$

FIGURE 2 — OUTPUT POWER versus INPUT POWER

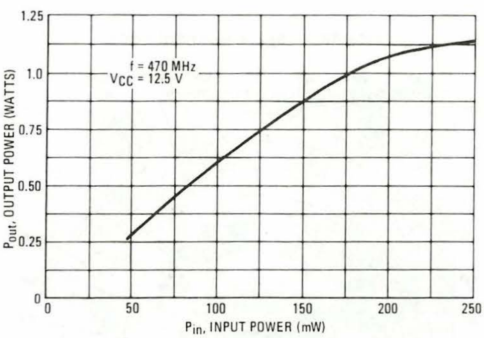


FIGURE 3 — CURRENT-GAIN — BANDWIDTH PRODUCT versus COLLECTOR CURRENT

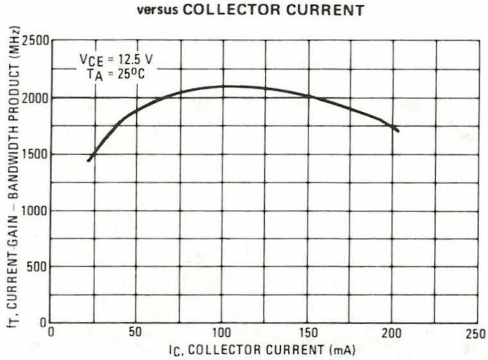


FIGURE 4 — OUTPUT CAPACITANCE versus COLLECTOR BASE VOLTAGE

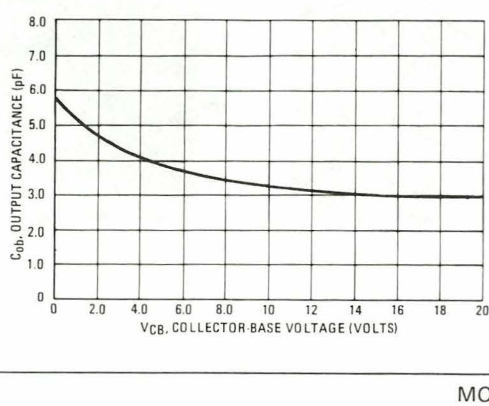
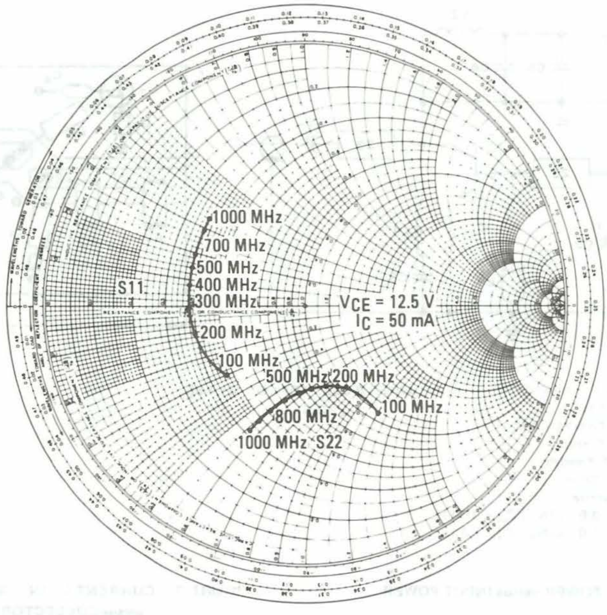


FIGURE 5 — S_{11} and S_{22} versus FREQUENCY



7

FIGURE 6 — S_{12} versus FREQUENCY

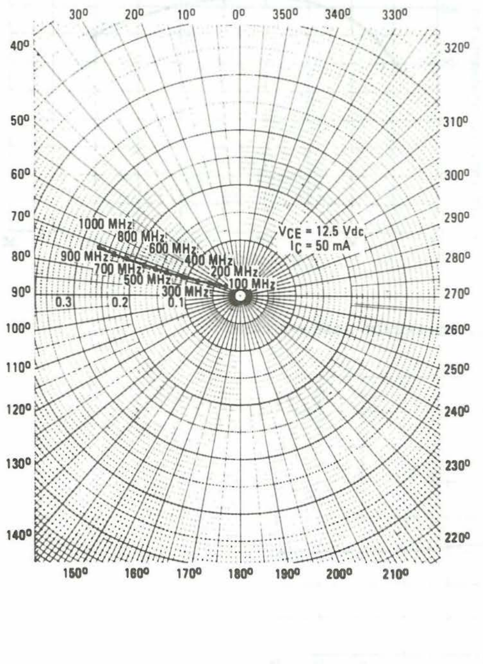
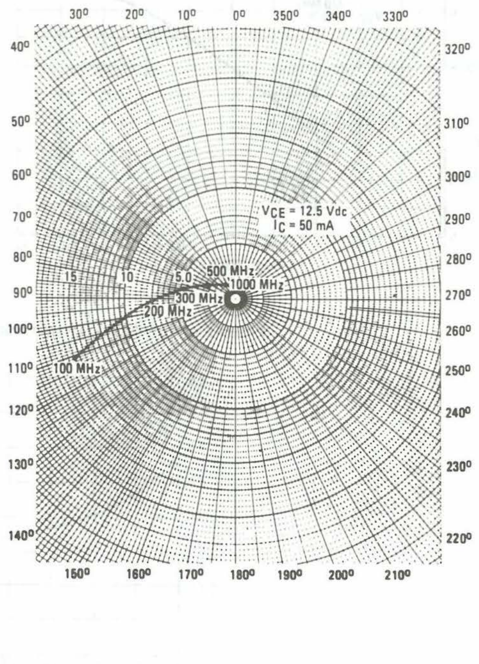


FIGURE 7 — S_{21} versus FREQUENCY



MRF517

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage (R_{BE} = 330Ω)	V_{CER}	25	Vdc
Collector-Base Voltage	V_{CBO}	35	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	150	mAdc
Total Device Dissipation @ T_C = 50°C Derate above 50°C	P_D	2.5 20.0	Watts mW/°C
Junction Temperature	T_J	+175	°C
Storage Temperature	T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, R_{BE} = 330 Ohms)	$V_{(BR)CER}$	25	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	35	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	I_{CEO}	—	—	100	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 60 mAdc, V_{CE} = 10 Vdc)	h_{FE}	40	—	200	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 60 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	2200	2700	—	MHz
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	3.0	4.5	pF
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain (V_{CE} = 15 Vdc, I_C = 60 mAdc, f = 300 MHz)	G_{pe}	—	10	—	dB
Broadband Noise Figure (V_{CE} = 15 Vdc, I_C = 50 mAdc, f = 300 MHz)	NF	—	—	7.5	dB
2nd Order Distortion (V_{CE} = 15 Vdc, I_C = 60 mAdc, E_{out} = +45 dBmV, Ch 2 + Ch G = 212.5 MHz)	IMD_2	—	—	−57	dB
NCTA Cross Modulation Distortion, 12 Ch's (2–13) (V_{CE} = 15 Vdc, I_C = 60 mAdc, E_{out} = +45 dBmV, Measured at Ch's 2 and 13)	XMD_{12}	—	—	−57	dB
Triple Beat Distortion, 3 Ch's (V_{CE} = 15 Vdc, I_C = 60 mAdc, E_{out} = +45 dBmV, Ch's (4 + 5 + A) = 265 MHz)	TB_3	—	—	−72	dB

FIGURE 1 – POWER DISSIPATION

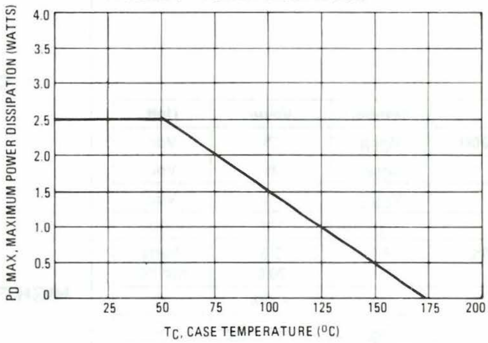
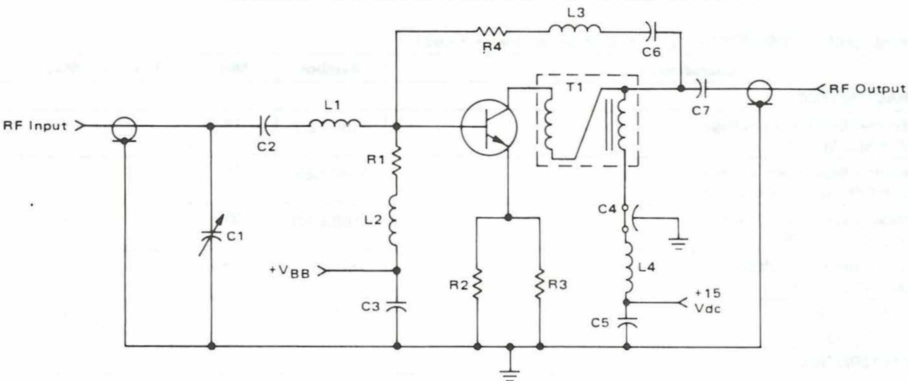


FIGURE 2 – 40 to 330 MHz BROADBAND TEST CIRCUIT SCHEMATIC



C1	1.0 – 10 pF JOHANSON	L4	VK200
C2,C6,C7	0.002 μF Ceramic Disk	T1	16:1 Bifilar Wound, #20 AWG Enameled Wire, Wound on a FERROXCUBE 1041T060-4C4 Core
C3,C5	0.1 μF, 50 Vdc Tantalum	R1	4.7 kΩ, 1/4 Watt, 10%
C4	1000 pF Button	R2,R3	27 Ω , 1/4 Watt, 5%
L1	1 Turn, #20 AWG	R4	270 Ω, 1/4 Watt, 5%
L2	5.6 μH Molded Choke		
L3	4 Turns, #20 AWG, 1/4" I.D.		

Input/Output Connectors – Type F
Z_o = 75 Ohms

FIGURE 3 – TYPICAL RESPONSE CURVE
(See Figure 2)

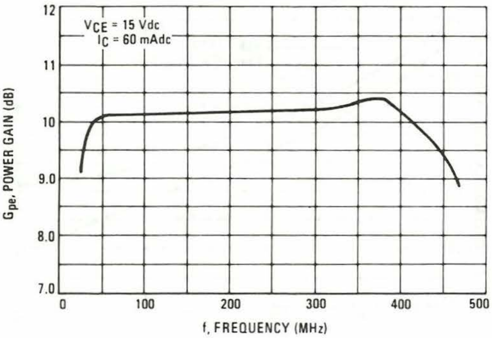


FIGURE 4 – COMMON-EMITTER POWER GAIN versus FREQUENCY

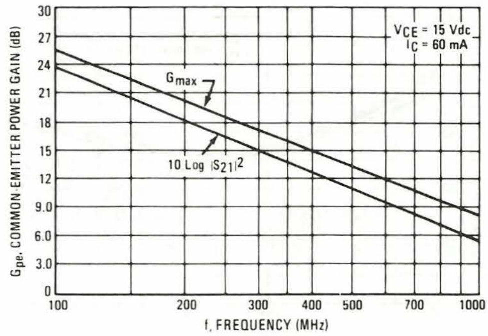


FIGURE 5 – CURRENT GAIN BANDWIDTH PRODUCT versus COLLECTOR CURRENT

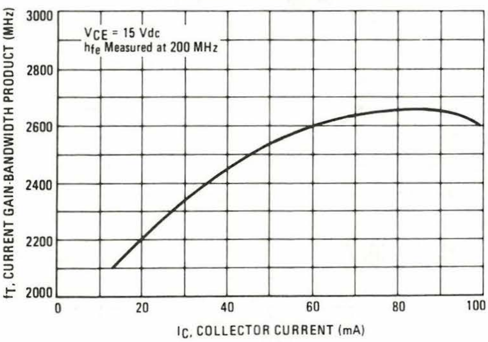


FIGURE 6 – INPUT CAPACITANCE versus EMITTER-BASE VOLTAGE

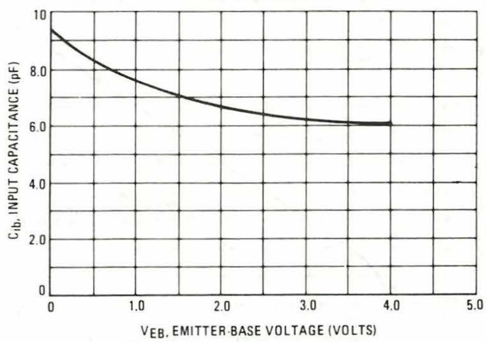


FIGURE 7 – OUTPUT CAPACITANCE versus COLLECTOR-BASE VOLTAGE

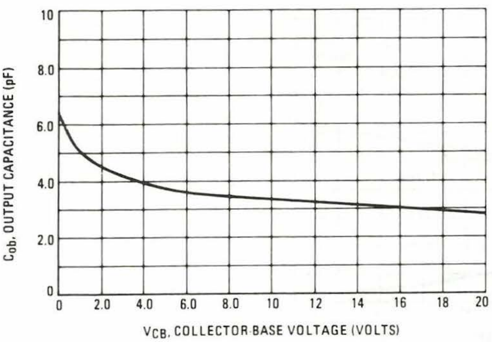
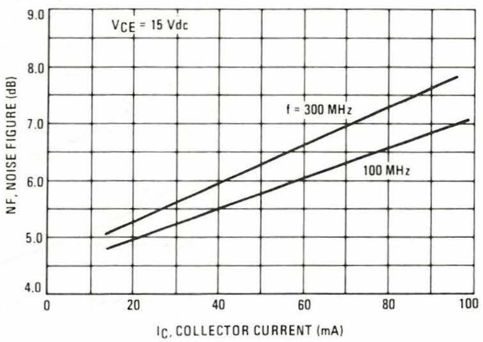


FIGURE 8 – BROADBAND NOISE FIGURE versus COLLECTOR CURRENT



7

FIGURE 9 — 2nd ORDER DISTORTION ($f_1 \pm f_2$) versus COLLECTOR CURRENT

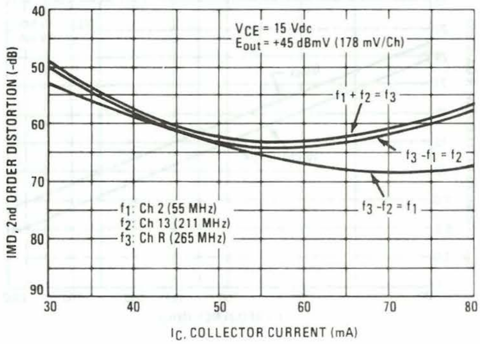


FIGURE 10 — 12-CHANNEL CROSS MODULATION DISTORTION versus COLLECTOR CURRENT

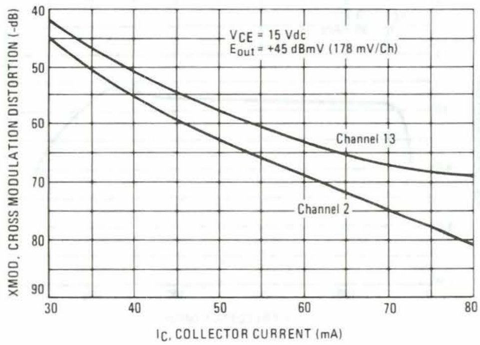


FIGURE 11 — DIN 45004 CROSS-MODULATION DISTORTION

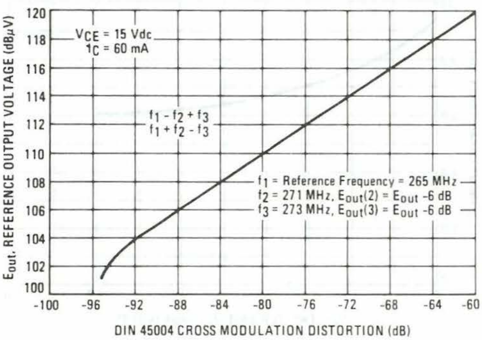


FIGURE 12 — TRIPLE BEAT DISTORTION ($f_1 + f_2 + f_3$) versus COLLECTOR CURRENT

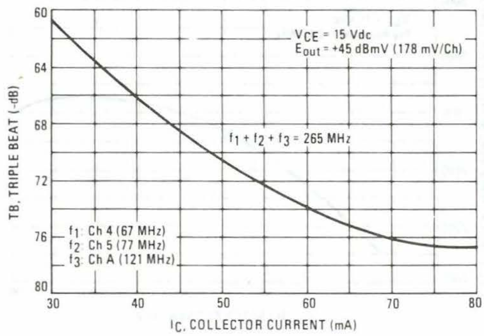
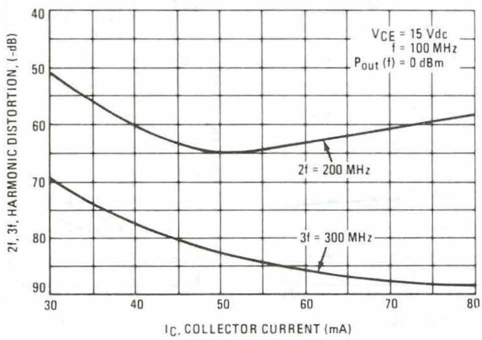


FIGURE 13 — HARMONIC DISTORTION (2f, 3f) versus COLLECTOR CURRENT



V_{CE} (Volts)	I_C (mA)	Frequency (MHz)	S11 |S11|	S11 ∠φ	S21 |S21|	S21 ∠φ	S12 |S12|	S12 ∠φ	S22 |S22|	S22 ∠φ
		100	0.538	-152	12.821	100	0.043	49	0.381	-102
		200	0.546	-173	6.612	86	0.064	55	0.314	-121
5	30	400	0.557	163	3.440	71	0.105	60	0.315	-132
		600	0.602	147	2.357	59	0.144	61	0.360	-140
		800	0.625	136	1.872	46	0.181	59	0.437	-143
		1000	0.626	120	1.614	34	0.211	57	0.482	-144
		100	0.532	-160	13.475	98	0.040	54	0.362	-111
		200	0.542	-178	6.850	86	0.063	60	0.314	-130
		400	0.558	160	3.586	72	0.109	63	0.313	-140
	60	600	0.602	145	2.475	60	0.151	62	0.353	-146
		800	0.619	134	1.962	48	0.190	59	0.423	-147
		1000	0.616	118	1.706	35	0.221	57	0.464	-147
		100	0.532	-163	13.530	98	0.038	57	0.354	-115
		200	0.545	179	6.908	85	0.063	62	0.313	-133
		400	0.558	159	3.607	72	0.111	64	0.312	-143
	90	600	0.604	145	2.489	61	0.153	63	0.352	-148
		800	0.620	133	1.982	48	0.193	59	0.419	-149
		1000	0.614	117	1.721	35	0.224	57	0.455	-148
		100	0.500	-145	14.176	102	0.040	50	0.386	-87
		200	0.502	-170	7.358	87	0.059	55	0.304	-105
		400	0.512	164	3.819	71	0.097	61	0.304	-118
10	30	600	0.559	149	2.593	59	0.133	62	0.356	-128
		800	0.583	137	2.033	46	0.166	60	0.442	-134
		1000	0.584	122	1.724	34	0.194	59	0.497	-137
		100	0.487	-154	14.977	100	0.037	55	0.353	-96
		200	0.498	-174	7.715	86	0.059	60	0.287	-114
	60	400	0.506	161	4.009	72	0.101	63	0.294	-125
		600	0.553	146	2.731	60	0.139	63	0.341	-133
		800	0.572	135	2.158	47	0.174	60	0.422	-137
		1000	0.569	119	1.835	35	0.202	58	0.475	-139
		100	0.486	-157	15.192	99	0.036	57	0.337	-98
		200	0.493	-176	7.764	86	0.058	61	0.280	-116
		400	0.508	160	4.043	72	0.101	64	0.287	-126
	90	600	0.555	145	2.761	60	0.141	63	0.336	-134
		800	0.574	134	2.184	47	0.176	60	0.417	-138
		1000	0.568	118	1.861	35	0.204	58	0.469	-139
		100	0.465	-153	15.774	100	0.035	56	0.337	-88
		200	0.475	-174	8.091	86	0.056	61	0.274	-105
		400	0.487	161	4.209	71	0.097	64	0.284	-116
15	30	600	0.532	146	2.863	59	0.133	63	0.337	-126
		800	0.551	135	2.249	47	0.167	60	0.425	-132
		1000	0.547	119	1.909	34	0.193	58	0.482	-135
		100	0.468	-150	15.650	101	0.036	54	0.354	-87
		200	0.475	-172	8.088	87	0.057	60	0.282	-104
	60	400	0.486	163	4.178	72	0.096	63	0.290	-116
		600	0.530	147	2.846	60	0.133	63	0.341	-126
		800	0.549	136	2.228	47	0.166	60	0.429	-132
		1000	0.547	120	1.887	34	0.192	59	0.487	-135
		100	0.487	-141	14.773	103	0.039	50	0.391	-80
		200	0.486	-167	7.724	87	0.057	55	0.303	-97
	90	400	0.491	166	3.986	71	0.093	61	0.306	-110
		600	0.537	150	2.694	59	0.127	62	0.359	-122
		800	0.565	138	2.108	45	0.159	60	0.448	-129
		1000	0.566	123	1.779	33	0.185	60	0.507	-134

MRF525

CASE 79-03, STYLE 5
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage R_{BE} = 330 Ω	V_{CER}	25	Vdc
Collector-Base Voltage	V_{CBO}	35	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	150	mAdc
Total Device Dissipation @ T_A = 50°C Derate above 50°C	P_D	2.5 0.017	Watts W/°C
Junction Temperature	T_J	+175	°C
Storage Temperature	T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

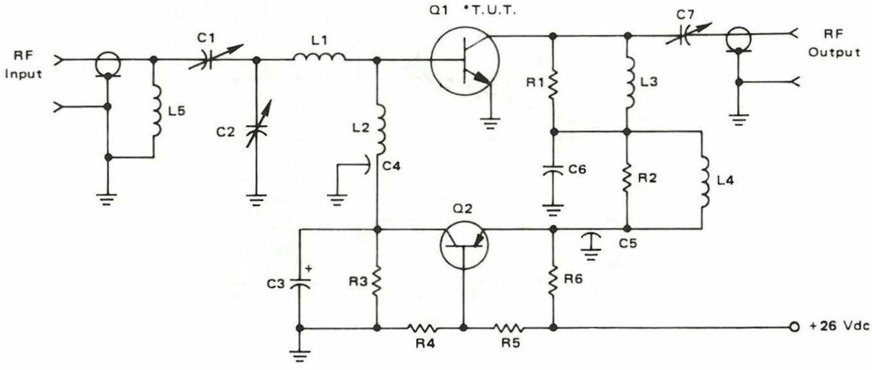
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	60	°C/W

7

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, R_{BE} = 330 Ohms)	$V_{(BR)CER}$	25	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mA, I_E = 0)	$V_{(BR)CBO}$	35	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mA, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	I_{CEO}	—	—	100	μA
ON CHARACTERISTICS					
DC Current Gain (I_C = 80 mAdc, V_{CE} = 10 Vdc)	h_{FE}	60	—	175	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 200 MHz)	f_T	2.2	2.5	—	GHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	3.0	4.0	pF
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain (V_{CC} = 26 Vdc, P_{in} = 0 dBm, f = 400 MHz)	G_{PE}	13	14	—	dB
Broadband Noise Figure (V_{CE} = 26 Vdc, f = 400 MHz)	NF	—	—	4.0	dB

FIGURE 1 — 225 to 400 MHz BROADBAND TEST CIRCUIT SCHEMATIC



C1, C2 — 2.5-11 pF Erie Ceramic Variable
C3 — 47 μF 6.0 Volt Electrolytic
C4, C5 — 1000 pF Feedthru
C6 — 470 pF Ceramic Chip
C7 — 5.5-18 pF Erie Ceramic Variable

R1 — 150 Ω 1/8 Watt Carbon
R2 — 100 Ω 1/8 Watt Carbon
R3, R4 — 10 kΩ 1/8 Watt Carbon
R5 — 3.3 kΩ 1/8 Watt Carbon

R6 — 120 Ω 1/2 Watt Carbon

L1 — 1 Turn #24, 0.125 mil ID
L2, L4 — 0.47 μH Molded Choke
L3 — 2 Turns #24, 0.125 mil ID
L5 — 4 Turns #24, 0.125 mil ID

Q2 — 2N2907A

*Transistor Under Test
I_E = 47 mAdc (Nominal)

FIGURE 2 — COMMON-EMITTER POWER GAIN (G_{max}) versus FREQUENCY

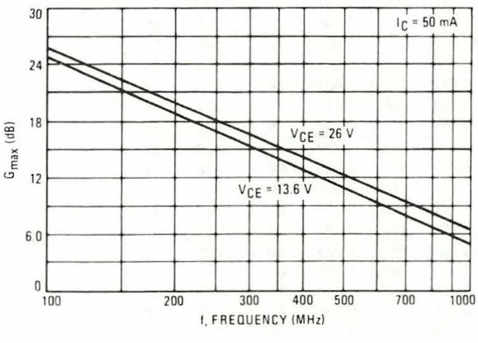


FIGURE 3 — CURRENT GAIN BANDWIDTH PRODUCT versus COLLECTOR CURRENT

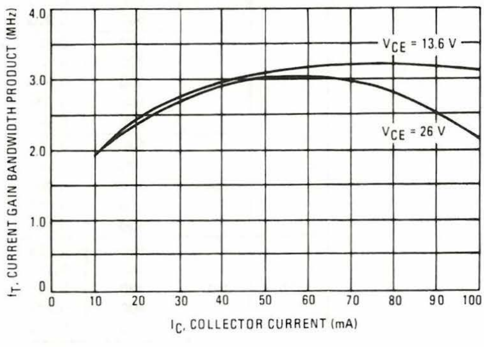


FIGURE 4 — BROADBAND AMPLIFIER RESPONSE

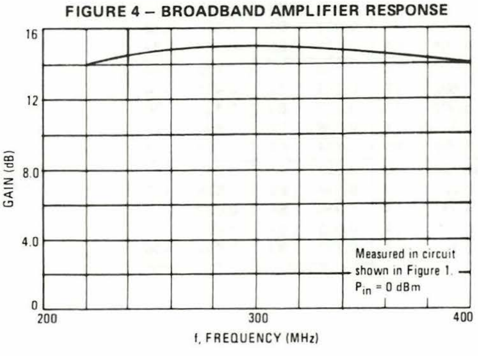


FIGURE 5 — 1.0 dB GAIN COMPRESSION OUTPUT versus FREQUENCY

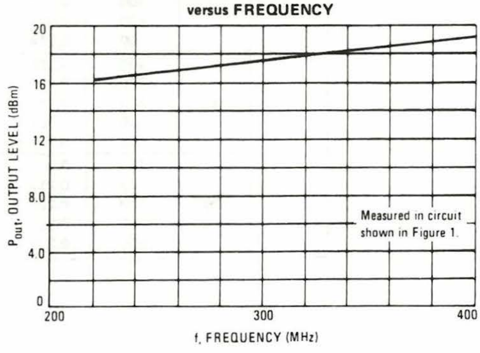
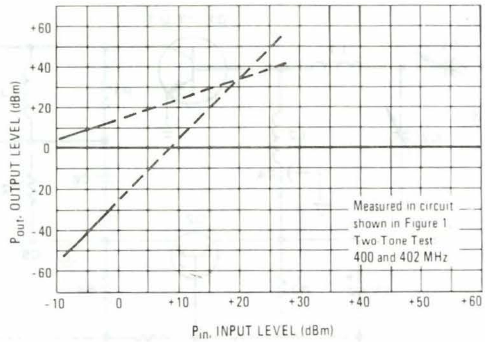


FIGURE 6 — THIRD ORDER INTERCEPT



S–PARAMETERS

V_{CE} (Volts)	I_C (mA)	Frequency (MHz)	S11		S21		S12		S22	
			|S11|	∠φ	|S21|	∠φ	|S12|	∠φ	|S22|	∠φ
		100	0.388	-111	12.318	107	0.032	61	0.597	-24
		200	0.331	-151	6.768	88	0.049	68	0.480	-25
13.6	10	300	0.337	-171	4.650	77	0.072	73	0.443	-31
		400	0.344	176	3.580	68	0.096	78	0.442	-40
		500	0.349	166	2.889	59	0.125	80	0.459	-47
		100	0.287	-125	14.160	103	0.030	67	0.516	-24
		200	0.263	-160	7.585	86	0.053	73	0.414	-23
	20	300	0.275	-177	5.167	76	0.078	76	0.378	-30
		400	0.288	172	3.968	68	0.104	77	0.378	-38
		500	0.293	164	3.214	60	0.135	78	0.396	-45
		100	0.206	-140	15.745	99	0.029	74	0.446	-24
		200	0.208	-171	8.299	84	0.056	76	0.358	-21
	50	300	0.226	176	5.612	75	0.084	76	0.324	-27
		400	0.235	169	4.307	68	0.113	77	0.326	-36
		500	0.243	161	3.488	60	0.114	76	0.345	-42
		100	0.179	-151	15.931	98	0.029	77	0.430	-22
		200	0.187	-177	8.293	85	0.058	80	0.358	-19
	100	300	0.203	171	5.626	77	0.087	80	0.330	-25
		400	0.212	164	4.276	70	0.115	80	0.338	-33
		500	0.213	157	3.456	63	0.147	79	0.364	-39
		100	0.454	-100	13.580	105	0.027	58	0.625	-15
		200	0.313	-138	7.339	88	0.040	67	0.552	-17
26	10	300	0.291	-161	4.989	78	0.060	76	0.532	-23
		400	0.287	-175	3.826	70	0.080	84	0.544	-30
		500	0.287	173	3.096	63	0.106	89	0.570	-36
		100	0.313	-105	15.191	102	0.025	62	0.566	-14
		200	0.220	-144	8.086	87	0.044	73	0.509	-15
	20	300	0.213	-166	5.487	77	0.067	78	0.489	-20
		400	0.215	-178	4.204	71	0.092	83	0.498	-28
		500	0.214	170	3.404	64	0.116	86	0.523	-34
		100	0.165	-117	16.375	102	0.026	71	0.529	-14
		200	0.139	-157	8.695	87	0.048	78	0.471	-14
	50	300	0.151	-176	5.882	78	0.073	80	0.449	-20
		400	0.157	173	4.494	71	0.098	82	0.458	-27
		500	0.158	164	3.659	65	0.124	84	0.485	-32
		100	0.215	-147	13.156	103	0.023	72	0.602	-14
		200	0.212	-176	7.220	88	0.044	82	0.536	-17
	100	300	0.222	171	4.951	79	0.069	84	0.507	-24
		400	0.230	164	3.851	72	0.093	87	0.513	-31
		500	0.233	156	3.123	64	0.123	89	0.534	-36

7

MRF531

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	100	Vdc
Collector-Base Voltage	V_{CBO}	100	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 14.3	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	70	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	100	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	100	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CE} = 75 Vdc, V_{BE} = 0)	I_{CES}	—	—	10	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	—	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	—	1.0	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 25 Vdc, f = 100 MHz)	f_T	500	800	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	—	4.0	pF
Input Capacitance (V_{BE} = 3.0 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	9.0	—	pF

FIGURE 1 — CURRENT-GAIN — BANDWIDTH PRODUCT

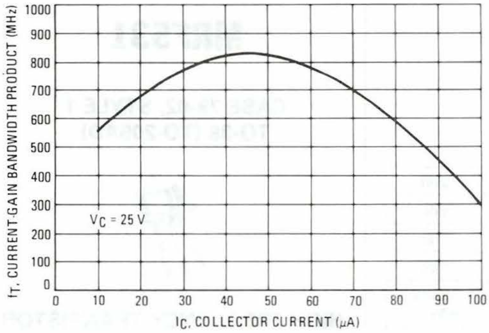


FIGURE 2 — INPUT CAPACITANCE

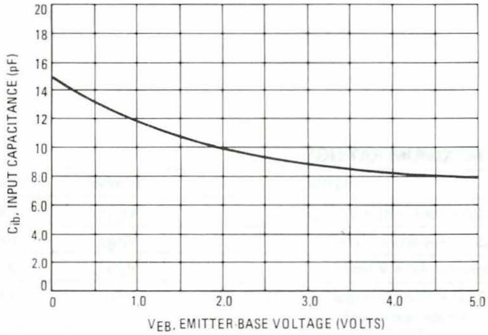


FIGURE 3 — OUTPUT CAPACITANCE

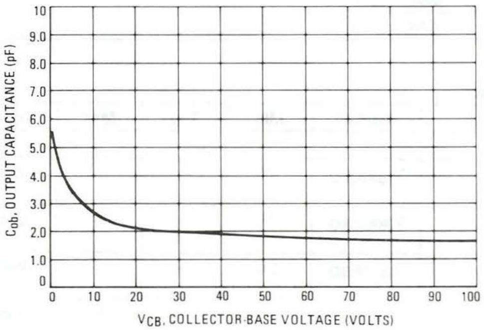
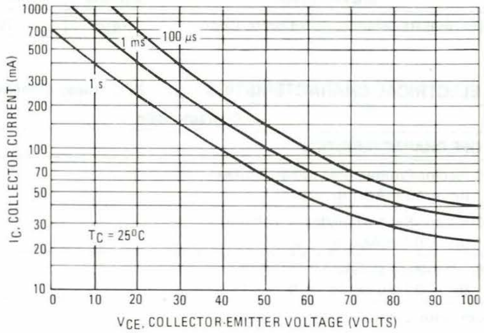


FIGURE 4 — DC SAFE OPERATING AREA



7

MRF532

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

PNP SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Volts
Collector-Base Voltage	V_{CBO}	80	Volts
Emitter-Base Voltage	V_{EBO}	3.5	Volts
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 14.3	Watts mW/°C
Storage Temperature	T_{stg}	−60 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	70	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mA)	$V_{(BR)CEO}$	80	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mA)	$V_{(BR)CBO}$	80	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mA)	$V_{(BR)EBO}$	3.5	—	Vdc
Collector Cutoff Current (V_{CE} = 75 V)	I_{CES}	—	10	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 5.0 mA, V_{CE} = 10 V)	h_{FE}	25	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_B = 1.0 mA)	$V_{CE(sat)}$	—	1.0	Vdc
SMALL SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mA, V_{CE} = 25 V, f = 100 MHz)	f_T	500	—	MHz
Output Capacitance (V_{CB} = 10 V, f = 1.0 MHz)	C_{obo}	—	4.0	pF

MRF534, MRF536

For Specifications, See MM4049 Data.

MRF559

CASE 317-01, STYLE 2

HIGH FREQUENCY TRANSISTOR

NPN SILICON

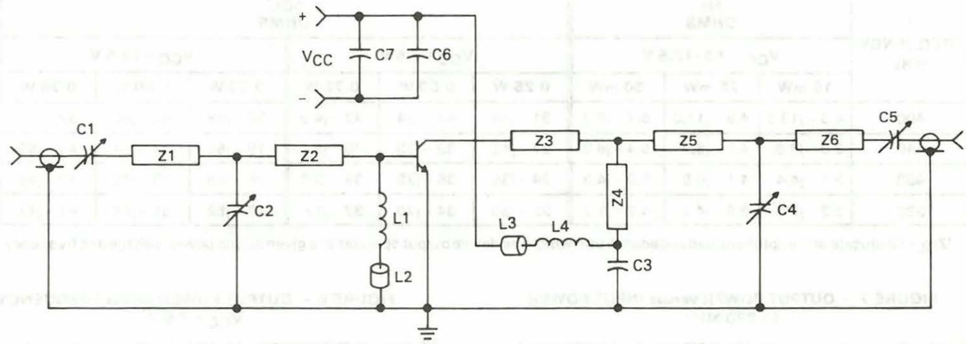
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	150	mAdc
Total Device Dissipation @ T_C = 50°C Derate above 50°C	P_D	2.0 20	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	18	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		$V_{(BR)CBO}$	36	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)		I_{CES}	—	—	1.0	mAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc)		h_{FE}	30	90	200	—
SMALL SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 200 MHz)		f_T	—	3000	—	MHz
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)		C_{obo}	—	2.0	2.5	pF
FUNCTIONAL TEST						
Common-Emitter Amplifier Power Gain (Figure 1) (V_{CC} = 12.5 Vdc, P_{out} = 0.5 W)	f = 870 MHz f = 512 MHz	G_{PE}	8.0 —	9.5 13	— —	dB
Collector Efficiency (Figure 1) (V_{CC} = 12.5 Vdc, P_{out} = 0.5 W)	f = 870 MHz f = 512 MHz	η	50 —	65 60	— —	%
TYPICAL PERFORMANCE @ V_{CC} = 7.5 V						
Common-Emitter Amplifier Power Gain (V_{CC} = 7.5 Vdc, P_{out} = 0.5 W)	f = 870 MHz f = 512 MHz	G_{PE}	— —	6.5 10	— —	dB
Collector Efficiency (V_{CC} = 7.5 Vdc, P_{out} = 0.5 W)	f = 870 MHz f = 512 MHz	η	— —	70 65	— —	%

FIGURE 1 — 870 MHz TEST FIXTURE



C1, C2, C4, C5 — 1.0-10 pF Johanson
C3, C6 — 0.001 μF Chip Capacitor
C7 — 1.0 μF Tantulam
L1, L4 — 4 Turns #26 AWG, 0.3 cm ID, 0.4 cm Long
L2, L3 — Ferrite Bead
Microstrip Elements — ϵ_r = 1.0

Z1 — 50 Ω 1.5 cm
Z2 — 30 Ω 2.5 cm
Z3 — 50 Ω 2.0 cm
Z4 — 50 Ω 1.2 cm
Z5, Z6 — 50 Ω 1.25 cm

FIGURE 2 — OUTPUT POWER versus INPUT POWER
f = 512 MHz

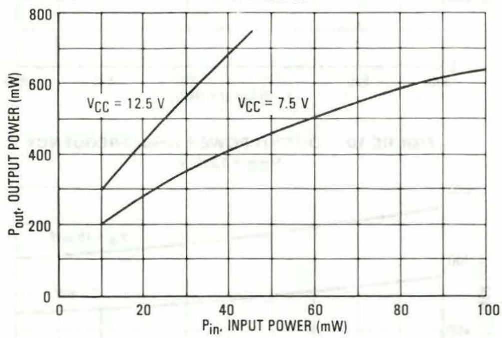


FIGURE 3 — OUTPUT POWER versus FREQUENCY
V_{CC} = 7.5 V

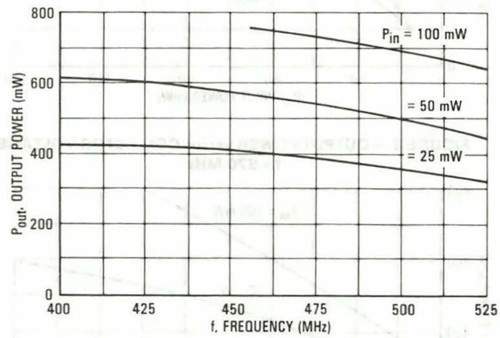


FIGURE 4 — OUTPUT POWER versus COLLECTOR VOLTAGE
f = 512 MHz

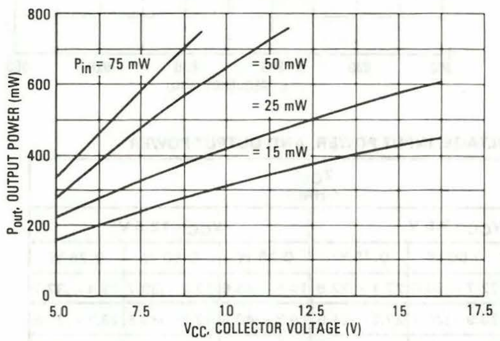


FIGURE 5 — OUTPUT POWER versus FREQUENCY
V_{CC} = 12.5 V

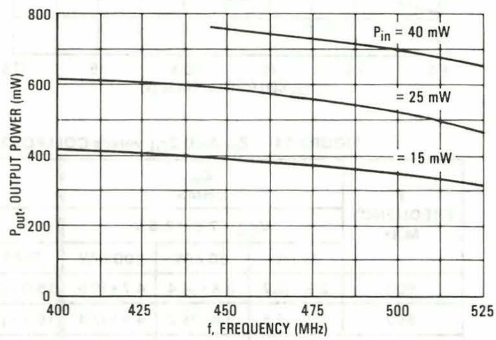


FIGURE 6 — Z_{in} AND Z_{OL} versus COLLECTOR VOLTAGE, INPUT POWER, AND OUTPUT POWER

f FREQUENCY MHz	Z_{in} OHMS			Z_{OL}* OHMS					
	V_{CC} = 7.5-12.5 V			V_{CC} = 7.5 V			V_{CC} = 12.5 V		
	15 mW	25 mW	50 mW	0.25 W	0.50 W	0.75 W	0.25 W	0.50 W	0.75 W
400	4.3 - j13.3	4.9 - j11.0	5.7 - j8.7	31 - j49	44 - j34	42 - j4.9	20 - j68	42 - j60	52 - j54
440	3.9 - j8.8	4.5 - j8.7	5.4 - j6.9	27 - j42	39 - j30	40 - j6.9	19 - j62	37 - j54	49 - j50
480	3.5 - j4.4	4.1 - j6.5	5.0 - j4.3	24 - j36	36 - j25	39 - j9.0	18 - j56	33 - j48	47 - j46
520	3.2 - j2.2	3.8 - j4.3	4.7 - j1.7	22 - j30	34 - j20	37 - j12	17 - j52	31 - j44	47 - j42

*Z_{OL} = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

FIGURE 7 — OUTPUT POWER versus INPUT POWER
f = 870 MHz

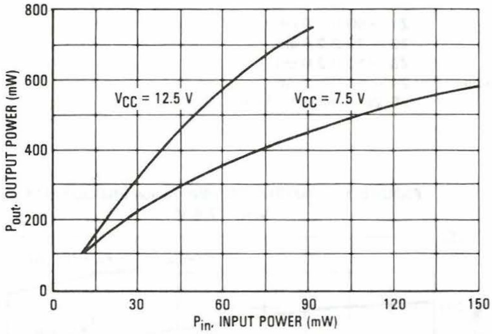
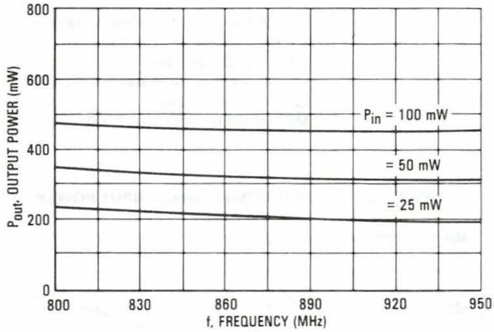


FIGURE 8 — OUTPUT POWER versus FREQUENCY
V_{CC} = 7.5 V



7

FIGURE 9 — OUTPUT POWER versus COLLECTOR VOLTAGE
f = 870 MHz

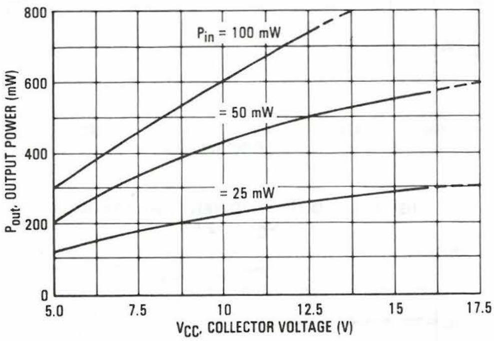


FIGURE 10 — OUTPUT POWER versus FREQUENCY
V_{CC} = 12.5 V

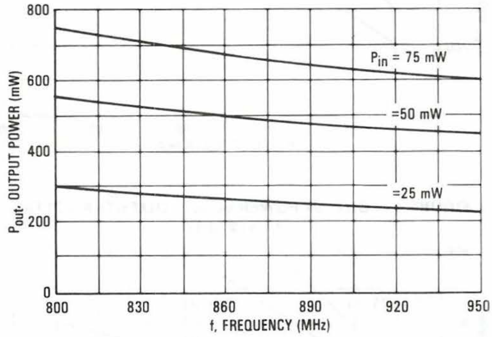


FIGURE 11 — Z_{in} AND Z_{OL} versus COLLECTOR VOLTAGE, INPUT POWER, AND OUTPUT POWER

f FREQUENCY MHz	Z_{in} OHMS			Z_{OL}* OHMS					
	V_{CC} = 7.5-12.5 V			V_{CC} = 7.5 V			V_{CC} = 12.5 V		
	25 mW	50 mW	100 mW	0.25 W	0.50 W	0.75 W	0.25 W	0.50 W	0.75 W
800	2.9 + j2.2	3.8 + j4.4	4.7 + j6.5	15.0 - j36.8	22.7 - j30.6	27.1 - j22.6	14.6 - j43.6	17.2 - j39.7	23.4 - j37.7
850	3.2 + j3.5	3.8 + j5.2	4.8 + j7.4	15.7 - j35.3	23.9 - j28.7	27.3 - j21.5	16.3 - j40.8	17.8 - j39.5	23.7 - j36.8
900	3.8 + j5.7	4.4 + j7.0	5.4 + j8.7	16.4 - j33.7	25.1 - j27.0	27.5 - j20.5	17.3 - j38.2	18.3 - j39.3	23.9 - j36.0
950	4.1 + j7.4	4.5 + j8.8	5.5 + j10.1	17.0 - j32.2	26.3 - j25.2	27.6 - j19.4	17.2 - j36.1	20.1 - j38.5	24.5 - j35.6

*Z_{OL} = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

FIGURE 12 — GAIN versus FREQUENCY
V_{CE} = 10 V, I_C = 50-100 mA

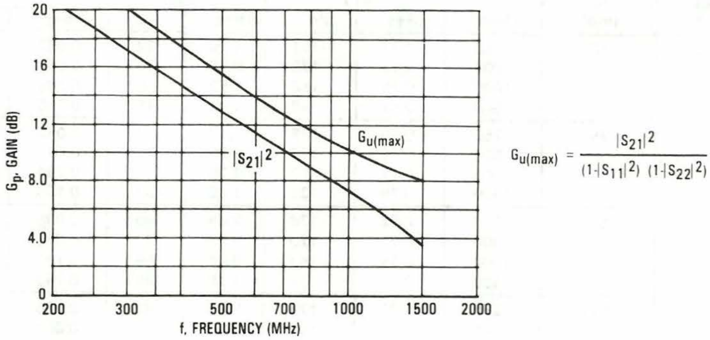


FIGURE 13 — GAIN versus COLLECTOR CURRENT
V_{CE} = 10 V

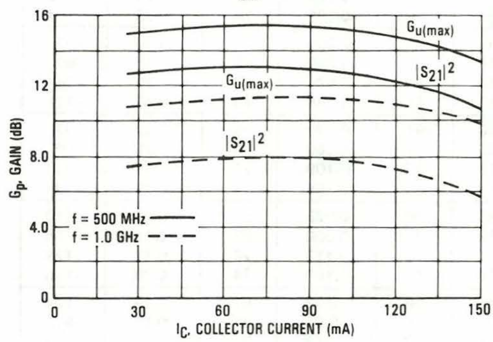


FIGURE 14 — NOISE FIGURE AND ASSOCIATED GAIN versus COLLECTOR CURRENT
V_{CE} = 10 V

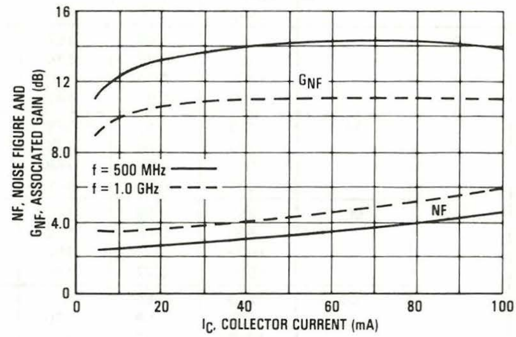


FIGURE 15 — CURRENT GAIN BANDWIDTH PRODUCT versus COLLECTOR CURRENT
V_{CE} = 10 V

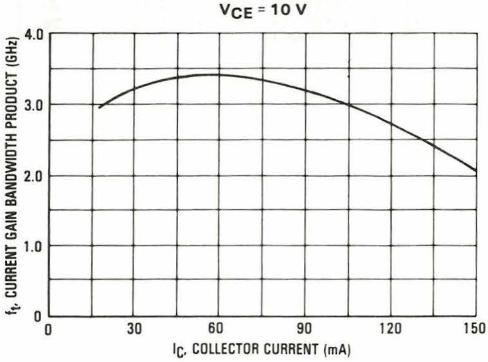
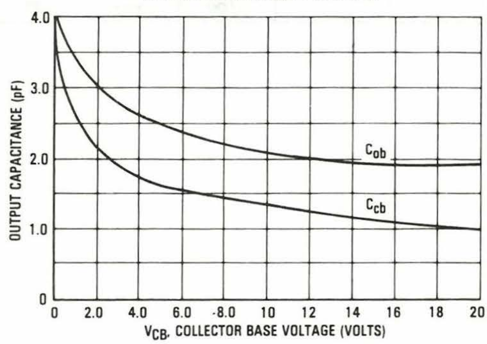


FIGURE 16 — OUTPUT CAPACITANCE versus COLLECTOR BASE VOLTAGE



7

FIGURE 17 — COMMON EMITTER SCATTERING PARAMETERS

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	$\angle\phi$	$\|S_{21}\|$	$\angle\phi$	$\|S_{12}\|$	$\angle\phi$	$\|S_{22}\|$	$\angle\phi$
5.0	10	250	0.72	-161	6.20	93	0.057	30	0.30	-91
		500	0.73	179	3.16	76	0.069	43	0.27	-94
		1000	0.76	158	1.62	55	0.105	63	0.27	-119
		1500	0.82	142	1.08	41	0.155	70	0.41	-137
	25	250	0.70	-173	7.17	89	0.045	47	0.26	-123
		500	0.70	172	3.63	75	0.073	60	0.20	-128
		1000	0.74	152	1.90	54	0.134	67	0.21	-157
		1500	0.79	136	1.32	39	0.196	66	0.32	-167
	50	250	0.72	-178	7.63	89	0.038	56	0.27	-139
		500	0.72	170	3.85	77	0068	67	0.23	-141
		1000	0.75	153	2.01	59	0.129	72	0.23	-162
		1500	0.81	137	1.40	46	0.188	70	0.32	-164
	100	250	0.73	179	7.34	88	0.036	61	0.26	-143
		500	0.74	169	3.70	77	0.067	71	0.22	-144
		1000	0.76	153	1.94	59	0.130	74	0.24	-166
		1500	0.81	138	1.36	46	0.191	71	0.32	-167
	150	250	0.78	176	5.19	92	0.033	64	0.22	-131
		500	0.78	167	2.76	78	0.065	74	0.21	-131
		1000	0.80	151	1.49	58	0.129	77	0.24	-155
		1500	0.85	135	1.05	45	0.191	73	0.35	-161
10	10	250	0.69	-157	7.03	94	0.050	33	0.34	-67
		500	0.70	-178	3.59	77	0.060	46	0.32	-69
		1000	0.74	160	1.84	55	0.094	67	0.29	-94
		1500	0.81	142	1.20	41	0.148	76	0.42	-121
	25	250	0.67	-168	8.30	91	0.039	46	0.24	-93
		500	0.68	176	4.25	77	0.060	60	0.21	-89
		1000	0.72	158	2.19	57	0.109	71	0.19	-114
		1500	0.78	142	1.47	44	0.165	74	0.31	-134
	50	250	0.68	-174	8.88	90	0.035	55	0.21	-110
		500	0.68	172	4.49	77	0.060	67	0.18	-104
		1000	0.72	155	2.31	59	0.113	74	0.17	-128
		1500	0.77	139	1.58	46	0.169	74	0.28	-140
	100	250	0.68	-178	8.49	89	0.03	61	0.19	-104
		500	0.69	170	4.32	76	0.06	71	0.17	-97
		1000	0.72	153	2.25	58	0.12	76	0.17	-123
		1500	0.78	137	1.53	44	0.18	75	0.28	-137
	150	250	0.72	178	6.53	91	0.029	64	0.22	-71
		500	0.73	169	3.37	77	0.056	75	0.24	-75
		1000	0.76	152	1.79	57	0.112	80	0.22	-105
		1500	0.83	137	1.22	43	0.175	79	0.34	-129

7

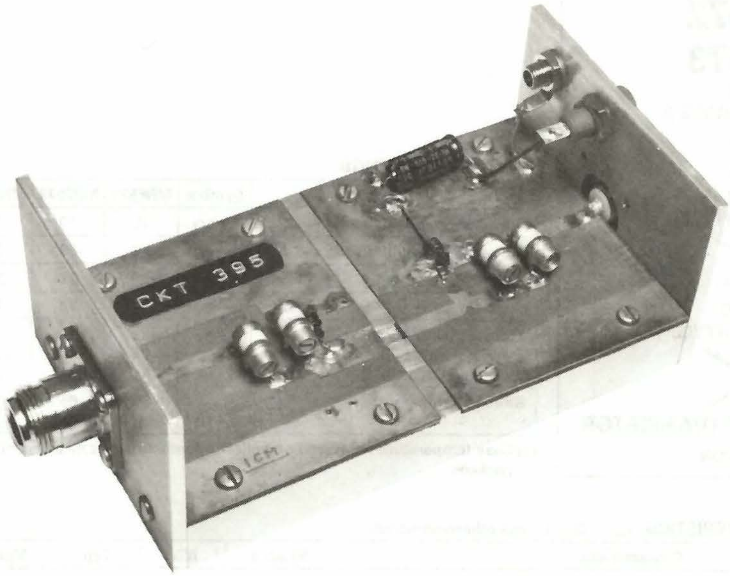
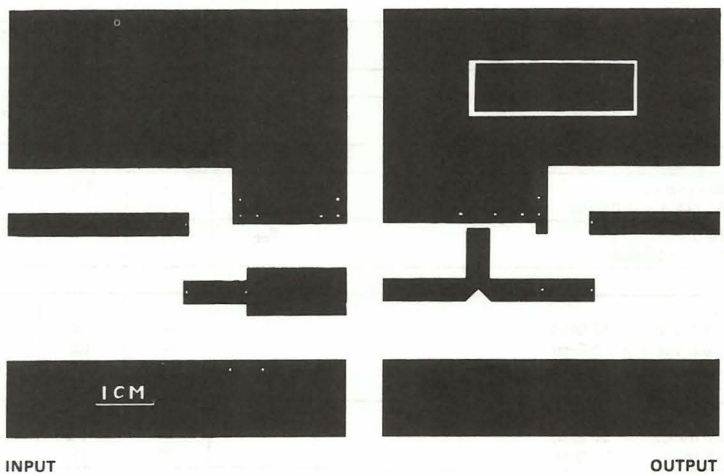


FIGURE 18 — TUNABLE TEST FIXTURE

FIGURE 19 — PRINTED CIRCUIT BOARD LAYOUT

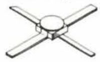


7

MRF571
MRF572
MRF573

MRF571
CASE 317-01, STYLE 2

MRF572
CASE 303-01, STYLE 1



MRF573
CASE 358-01, STYLE 1

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MRF571	MRF572	MRF573	Unit
Collector-Emitter Voltage	V_{CEO}	10	10	10	Vdc
Collector-Base Voltage	V_{CBO}	20	20	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	3.0	3.0	Vdc
Collector Current — Continuous	I_C	70	70	70	mAdc
Total Device Dissipation	P_D				
@ T_C = 100°C(1)		0.5	0.75	0.75	Watts
Derate above 100°C		5.0	7.5	7.5	mW/°C
Storage Temperature	T_{stg}	−65 to +150	−65 to +200	−65 to +200	°C

(1) Case temperature measured on collector lead immediately adjacent to body of package.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 0.1 mAdc, I_B = 0)	$V_{(BR)CEO}$	10	12	—	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 mAdc, I_E = 0)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 50 μAdc, I_C = 0)	$V_{(BR)EBO}$	2.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 8.0 Vdc, I_E = 0)	I_{CBO}	—	—	10	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 30 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	50	—	300	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (V_{CE} = 8.0 V_{DC}, I_C = 50 mA, f = 1.0 GHz)	f_T	—	8.0	—	GHz
Collector-Base Capacitance (V_{CB} = 6.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	.7	1.0	pF
FUNCTIONAL TEST					
Noise Figure	NF				dB
(I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = .50 GHz)		—	1.0	—	
(I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 GHz)		—	1.5	2.0	
(I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 2.0 GHz) MRF571		—	2.8	—	
(I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 2.0 GHz) MRF572,573		—	2.5	—	
Gain @ Noise Figure	G_{NF}				dB
(V_{CE} = 6.0 Vdc, I_C = 5.0 mAdc, f = .50 GHz)		—	16.5	—	
(V_{CE} = 6.0 Vdc, I_C = 5.0 mAdc, f = 1.0 GHz)		10	12	—	

FIGURE 1 — C_{cb}, COLLECTOR-BASE CAPACITANCE versus VOLTAGE

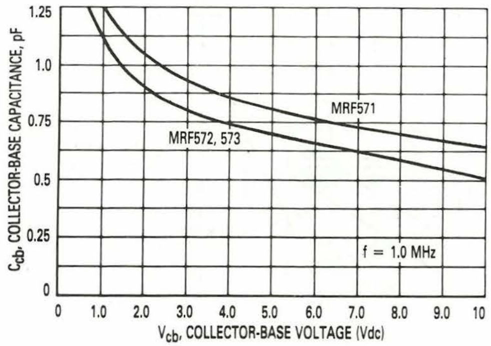


FIGURE 2 — C_{ib}, INPUT CAPACITANCE versus EMITTER BASE VOLTAGE

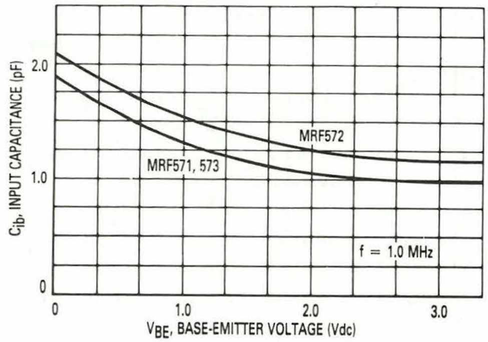


FIGURE 3 — MRF571 — GAIN AT NOISE FIGURE AND NOISE FIGURE versus FREQUENCY

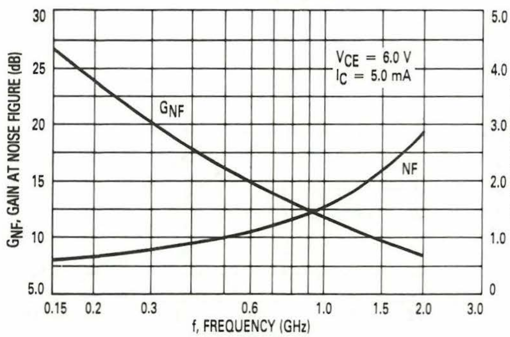


FIGURE 4 — MRF572, MRF573 — GAIN AT NOISE FIGURE AND NOISE FIGURE versus FREQUENCY

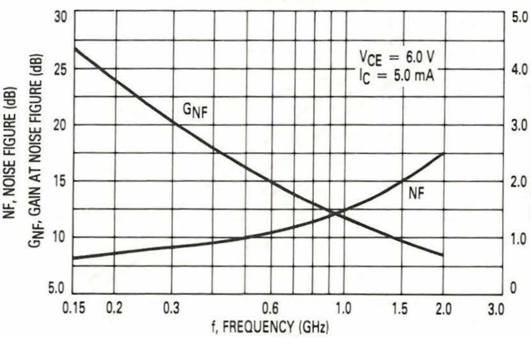


FIGURE 5 — MRF571, MRF572 and MRF573 — GAIN AT NOISE FIGURE AND NOISE FIGURE versus COLLECTOR CURRENT

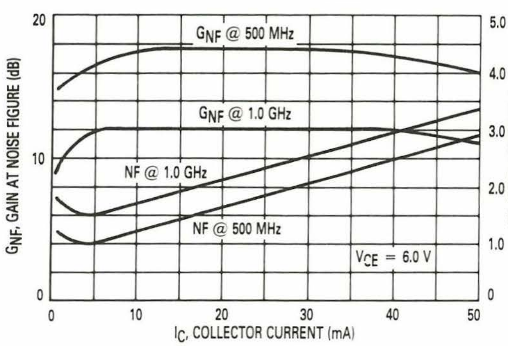
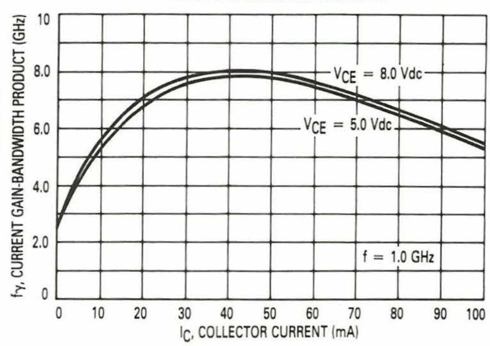


FIGURE 6 — f_T, CURRENT GAIN-BANDWIDTH PRODUCT versus COLLECTOR CURRENT



7

FIGURE 7 — G_A MAX, MAXIMUM AVAILABLE GAIN versus FREQUENCY

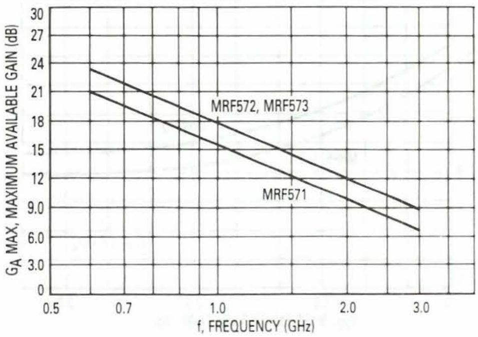


FIGURE 8 — 1.0 dB COMPRESSION PT. AND THIRD ORDER INTERCEPT

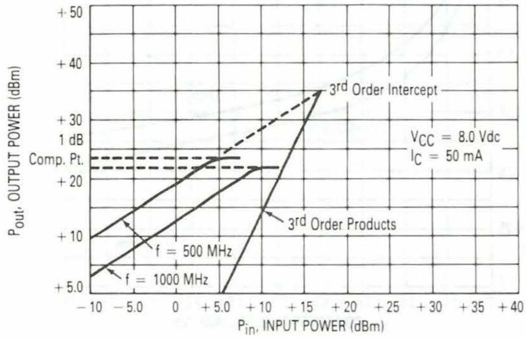


FIGURE 9 — MRF571 — $G_U$max and $|S_{21}|^2$ versus FREQUENCY

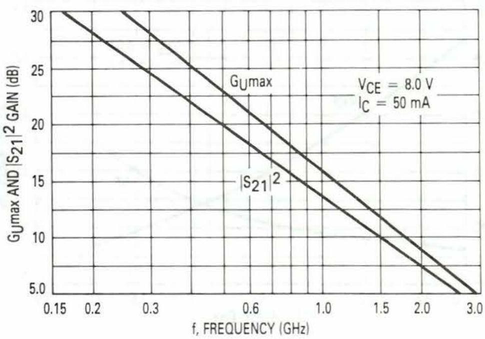
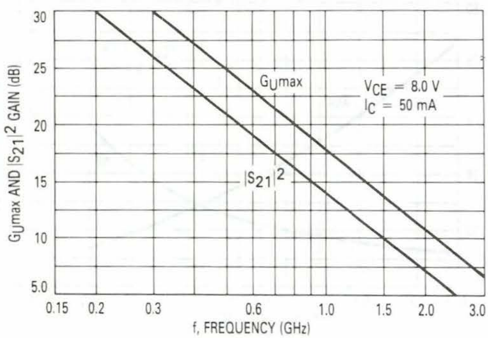
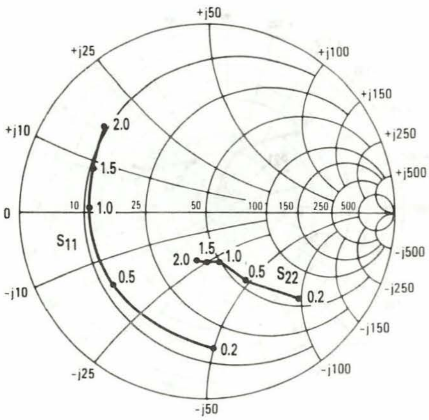


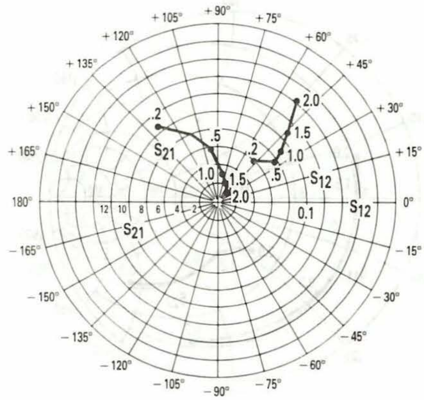
FIGURE 10 — MRF572, MRF573 — $G_U$max and $|S_{21}|^2$ versus FREQUENCY



MRF571
INPUT/OUTPUT REFLECTION COEFFICIENTS
versus FREQUENCY (GHz)
V_{CE} = 6.0 V, I_C = 5.0 mA



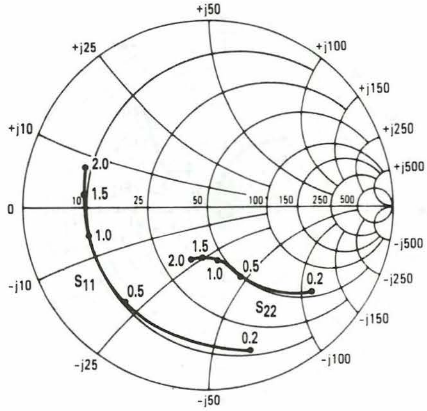
MRF571
FORWARD/REVERSE TRANSMISSION
COEFFICIENTS versus FREQUENCY (GHz)
V_{CE} = 6.0 V, I_C = 5.0 mA



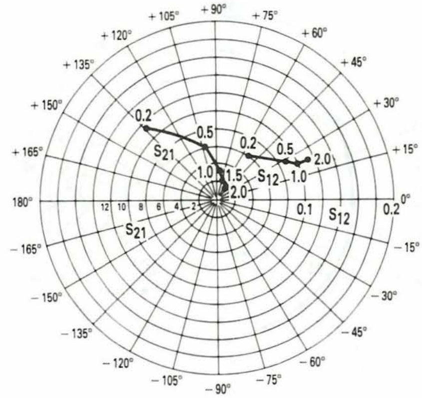
MRF571 COMMON EMITTER S-PARAMETERS

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	$\angle\phi$	$\|S_{21}\|$	$\angle\phi$	$\|S_{12}\|$	$\angle\phi$	$\|S_{22}\|$	$\angle\phi$
6.0	5.0	200	0.74	−86	10.5	129	0.06	48	0.69	−42
		500	0.62	−143	5.5	97	0.08	33	0.41	−59
		1000	0.61	178	3.0	78	0.09	37	0.28	−69
		1500	0.65	158	2.0	62	0.11	44	0.26	−88
		2000	0.70	140	1.6	51	0.14	51	0.27	−99
	10	200	0.64	−111	15	118	0.04	44	0.53	−59
		500	0.58	−160	6.9	93	0.06	42	0.27	−77
		1000	0.59	168	3.7	77	0.09	52	0.16	−91
		1500	0.63	151	2.5	64	0.12	56	0.16	−113
		2000	0.67	134	2.0	53	0.16	57	0.16	−118
	50	200	0.56	−160	20.4	102	0.02	57	0.27	−98
		500	0.57	176	8.4	86	0.05	67	0.14	−130
		1000	0.60	156	4.4	75	0.09	70	0.11	−164
		1500	0.62	152	2.9	64	0.13	68	0.13	−175
		2000	0.66	127	2.4	53	0.18	62	0.11	−178
8.0	5.0	200	0.75	−83	10.7	129	0.06	49	0.71	−39
		500	0.62	−140	5.1	98	0.08	34	0.43	−54
		1000	0.60	−179	3.7	78	0.09	38	0.31	−62
		1500	0.64	159	2.1	62	0.10	45	0.29	−80
		2000	0.69	141	1.7	52	0.13	52	0.29	−91
	10	200	0.64	−99	15.1	120	0.05	46	0.54	−60
		500	0.52	−152	7.1	94	0.07	45	0.32	−75
		1000	0.52	170	3.7	76	0.10	54	0.15	−82
		1500	0.52	150	2.5	62	0.13	56	0.16	−108
		2000	0.57	133	2.0	51	0.18	55	0.16	−107
	50	200	0.52	−153	19.6	102	0.03	56	0.28	−92
		500	0.52	178	8.1	86	0.05	67	0.16	−98
		1000	0.56	157	4.1	73	0.10	70	0.06	−130
		1500	0.54	139	2.8	62	0.13	68	0.11	−146
		2000	0.59	126	2.2	52	0.19	63	0.10	−137

MRF572
INPUT/OUTPUT REFLECTION COEFFICIENTS versus FREQUENCY (GHz)
V_{CE} = 6.0 V, I_C = 5.0 mA



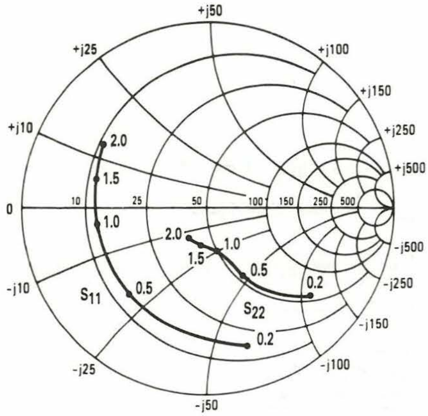
MRF572
FORWARD/REVERSE COEFFICIENTS versus FREQUENCY (GHz)
V_{CE} = 6.0 V, I_C = 5.0 mA



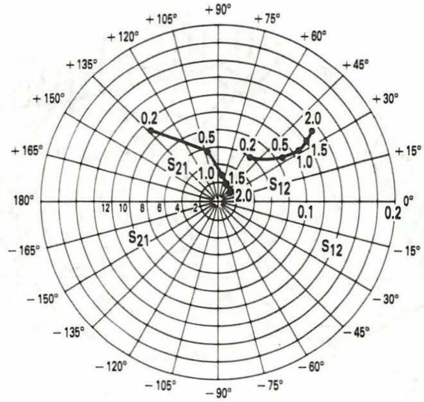
MRF572 COMMON EMITTER S-PARAMETERS

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11} $\|S_{11}\|$	S_{11} $\angle\phi$	S_{21} $\|S_{21}\|$	S_{21} $\angle\phi$	S_{12} $\|S_{12}\|$	S_{12} $\angle\phi$	S_{22} $\|S_{22}\|$	S_{22} $\angle\phi$
6.0	5.0	200	0.81	−73	10.9	134	0.06	50	0.74	−40
		500	0.68	−130	6.1	102	0.09	29	0.43	−64
		1000	0.66	−167	3.3	79	0.10	22	0.29	−77
		1500	0.66	174	2.3	63	0.10	22	0.27	−94
		2000	0.68	161	1.8	49	0.11	23	0.29	−104
	10	200	0.72	−101	15.9	123	0.05	43	0.57	−58
		500	0.66	−150	7.7	95	0.06	30	0.29	−86
		1000	0.66	−178	4.0	77	0.08	33	0.19	−103
		1500	0.67	166	2.7	63	0.09	36	0.19	−122
		2000	0.69	155	2.1	51	0.10	37	0.20	−129
	50	200	0.67	−154	21.8	104	0.02	43	0.30	−94
		500	0.68	−177	9.0	87	0.03	52	0.17	−129
		1000	0.70	167	4.5	74	0.06	58	0.14	−151
		1500	0.71	157	3.0	62	0.08	59	0.16	−160
		2000	0.73	148	2.3	51	0.10	55	0.17	−161
8.0	5.0	200	0.83	−69	10.9	136	0.06	52	0.75	−36
		500	0.71	−125	6.3	103	0.08	30	0.46	−57
		1000	0.64	−164	3.5	80	0.09	24	0.31	−68
		1500	0.65	176	2.4	63	0.10	23	0.29	−84
		2000	0.66	163	1.8	49	0.11	24	0.30	−94
	10	200	0.74	−94	16.2	125	0.05	45	0.60	−51
		500	0.65	−146	7.9	96	0.06	32	0.31	−74
		1000	0.64	−176	4.2	77	0.07	33	0.20	−87
		1500	0.65	168	2.8	63	0.09	36	0.19	−104
		2000	0.67	156	2.2	50	0.10	37	0.20	−111
	50	200	0.62	−150	22.7	104	0.02	43	0.30	−81
		500	0.64	−174	9.4	86	0.03	51	0.15	−107
		1000	0.68	167	4.8	74	0.05	58	0.10	−126
		1500	0.69	160	3.2	61	0.07	58	0.13	−140
		2000	0.70	147	2.4	50	0.09	55	0.15	−140

MRF573
INPUT/OUTPUT REFLECTION
COEFFICIENTS versus FREQUENCY (GHz)
V_{CE} = 6.0 V, I_C = 5.0 mA



MRF573
FORWARD/REVERSE COEFFICIENTS
versus FREQUENCY (GHz)
V_{CE} = 6.0 V, I_C = 5.0 mA

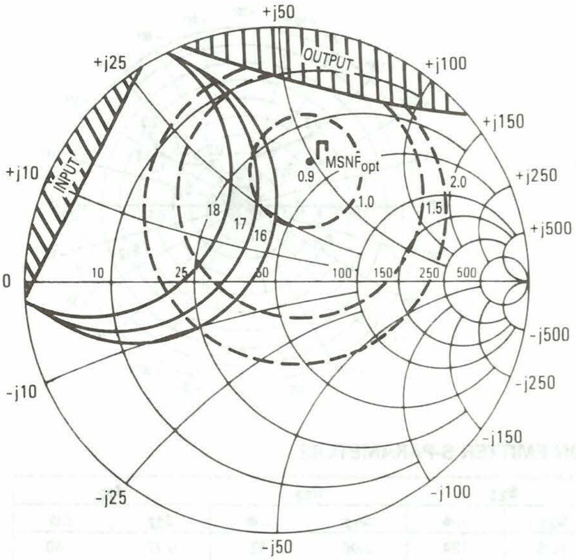


MRF573 COMMON EMITTER S-PARAMETERS

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	$\angle\phi$	$\|S_{21}\|$	$\angle\phi$	$\|S_{12}\|$	$\angle\phi$	$\|S_{22}\|$	$\angle\phi$
6.0	5.0	200	0.76	−73	10.6	134	0.06	52	0.72	−40
		500	0.61	−132	6.0	100	0.09	35	0.41	−63
		1000	0.59	−173	3.2	77	0.11	33	0.24	−76
		1500	0.61	165	2.2	59	0.12	35	0.19	−99
		2000	0.64	149	1.8	45	0.13	36	0.18	−117
	10	200	0.64	−99	15.1	122	0.05	48	0.56	−55
		500	0.56	−152	7.2	94	0.07	41	0.27	−81
		1000	0.58	175	3.8	74	0.09	45	0.14	−102
		1500	0.60	158	2.6	60	0.12	47	0.13	−135
		2000	0.64	144	2.0	46	0.13	45	0.13	−155
	50	200	0.54	−153	19.6	104	0.03	55	0.29	−83
		500	0.56	−179	8.1	85	0.05	62	0.13	−115
		1000	0.59	162	4.1	71	0.09	63	0.08	−157
		1500	0.61	150	2.8	58	0.12	60	0.12	179
		2000	0.65	138	2.1	46	0.13	54	0.14	165
8.0	5.0	200	0.78	−67	10.6	136	0.06	54	0.75	−36
		500	0.61	−125	6.1	102	0.09	36	0.44	−56
		1000	0.57	−169	3.4	78	0.10	33	0.27	−66
		1500	0.59	168	2.3	60	0.12	35	0.21	−84
		2000	0.62	151	1.8	46	0.14	36	0.19	−100
	10	200	0.66	−92	15.3	125	0.05	49	0.60	−49
		500	0.55	−147	7.5	95	0.07	41	0.30	−70
		1000	0.55	178	3.9	75	0.09	45	0.16	−81
		1500	0.57	160	2.7	60	0.12	47	0.12	−109
		2000	0.62	146	2.1	47	0.13	45	0.11	−130
	50	200	0.53	−147	20.8	105	0.02	47	0.31	−73
		500	0.53	−176	9.0	87	0.04	57	0.16	−90
		1000	0.57	166	4.5	72	0.07	61	0.06	−110
		1500	0.59	151	3.1	61	0.11	59	0.07	−154
		2000	0.63	143	2.3	49	0.13	55	0.09	−172

7

MRF571 — CONSTANT GAIN and NOISE FIGURE CONTOURS

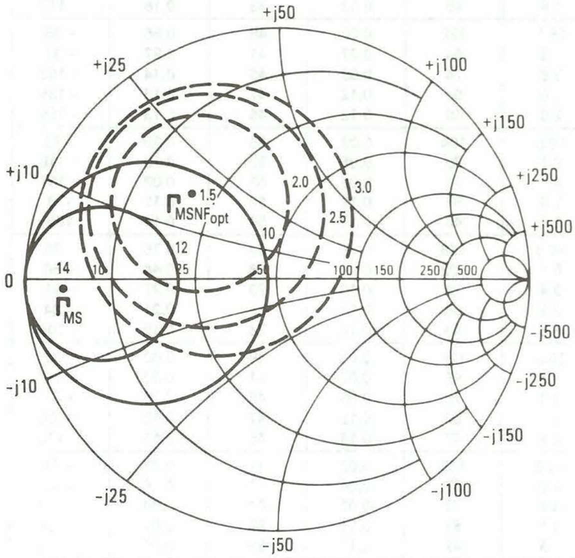


V_{CE} = 6.0 V, I_C = 5.0 mA
f = 500 MHz
▧ — REGION OF INSTABILITY

f(GHz)	NF_{OPT}(dB)	Rn (Ω)	NF50 Ω (dB)
0.5	0.9	9.3	1.3

$\Gamma msNF_{OPT}$	K
0.49 ∠74°	0.58

7

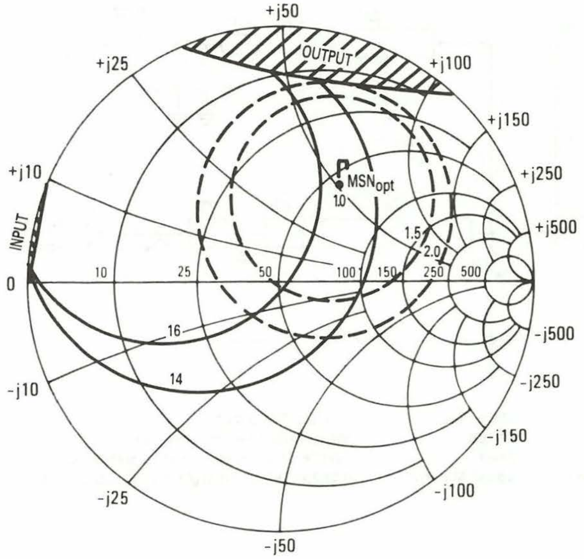


V_{CE} = 6.0 V, I_C = 5.0 mA
f = 1.0 GHz

f(GHz)	NF_{OPT}(dB)	Rn (Ω)	NF50 Ω (dB)	$\Gamma msNF_{OPT}$
1.0	1.5	7.5	2.2	0.48 ∠134°

Γms	ΓmL
0.89 ∠−179°	0.81 ∠66°

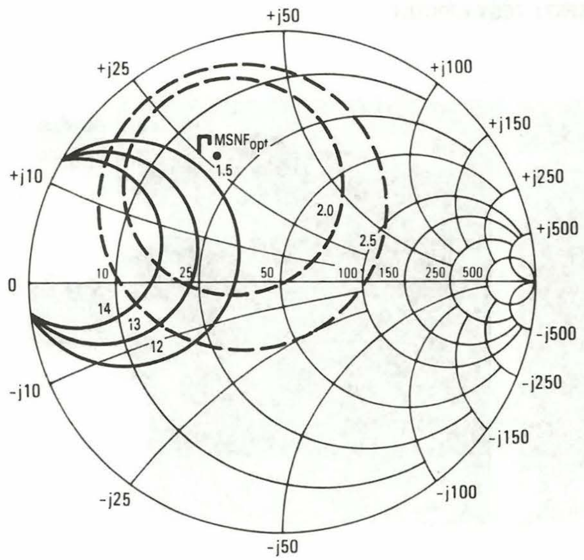
MRF572, MRF573 — CONSTANT GAIN and NOISE FIGURE CONTOURS



V_{CE} = 6.0 V, I = 5.0 mA
f = 500 MHz
— REGION OF INSTABILITY

f(GHz)	Rn (Ω)	NF (50Ω)	ΓmsNF$_{OPT}$
0.5	17.1	1.5	0.43 ∠ 57°

K	NF$_{OPT}$
0.55	1.0



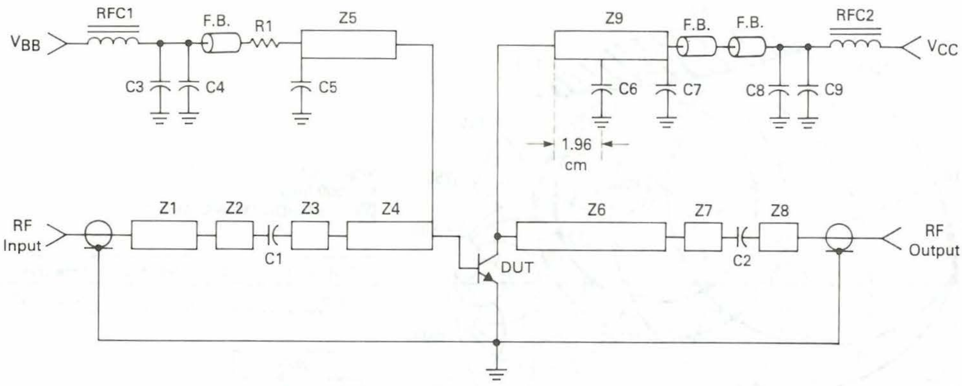
V_{CE} = 6.0 V, I_C = 5.0 mA
f = 1.0 GHz

f(GHz)	NF$_{OPT}$	Rn (Ω)	NF50 (Ω) (dB)
1.0	1.5	6.0	2.0

ΓmsNF$_{OPT}$	K
0.56 ∠ 116°	0.93

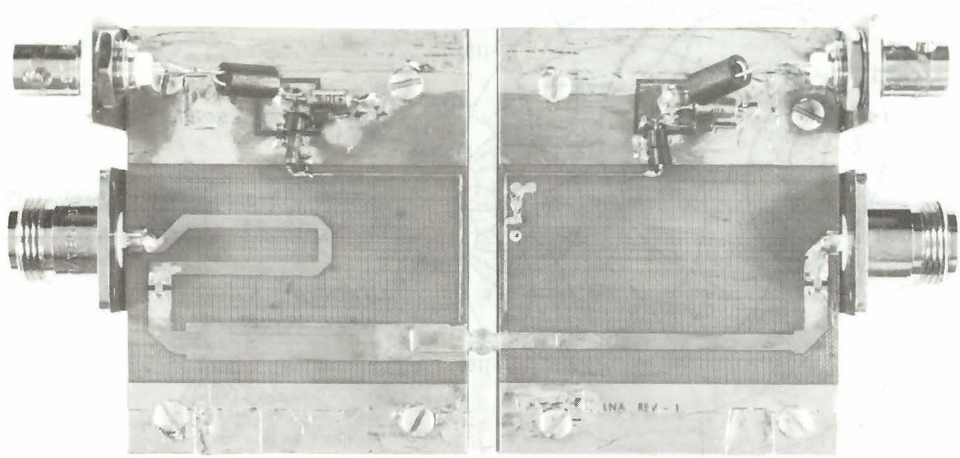
7

MRF571 1.0 GHz TEST CIRCUIT

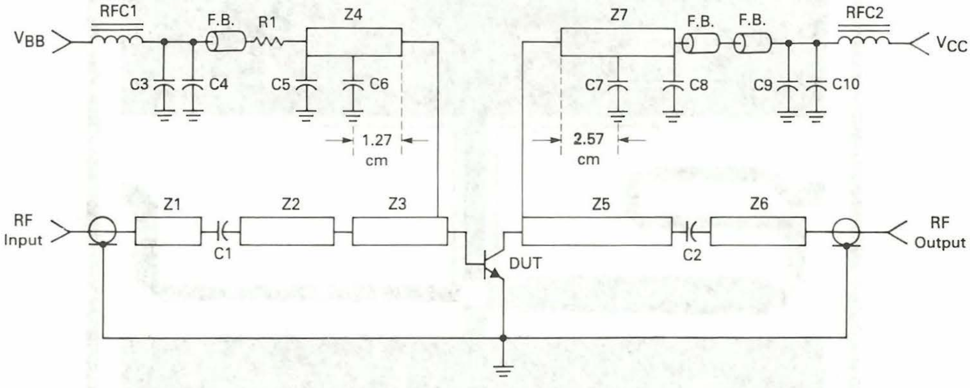


C1, C2, C6	560 pF Chip Capacitor	RFC1, RFC2	VK-200, Ferroxcube
C5, C7	0.018 μF Chip Capacitor	Z1–Z9	Microstrip, See Photomaster
C3, C8	0.1 μF Mylar Capacitor	Bead	Ferrite Bead, Ferroxcube 56-590-65/3B
C4, C9	1.0 μF Electrolytic Capacitor	Board Material	0.0625" Teflon Fiberglass ϵ_r = 2.5 ± 0.05
R1	2.7 kΩ		

MRF571 TEST CIRCUIT

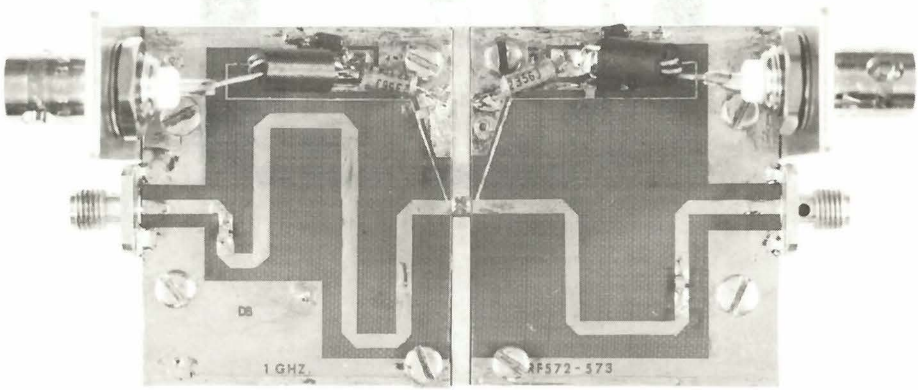


MRF572, 573 1.0 GHz TEST FIXTURE



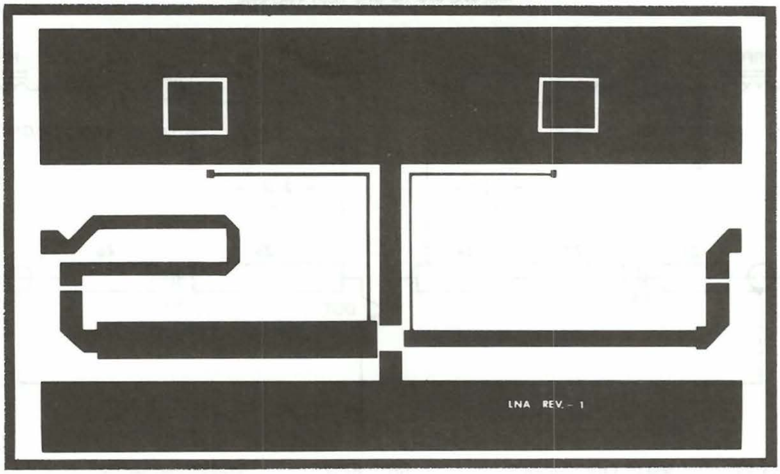
C1, C2, C6, C7	560 pF Chip Capacitor	RFC1, RFC2	VK-200, Ferroxcube
C5, C8	0.018 μF Chip Capacitor	Z1–Z7	Microstrip, See Photomaster
C3, C9	0.1 μF Mylar Capacitor	Bead	Ferrite Bead, Ferroxcube 56-590-65/3B
C4, C10	1.0 μF Electrolytic Capacitor	Board Material	0.031″ Teflon Fiberglass ϵ_r = 2.5 ± 0.05
R1	2.7 kΩ		

MRF572, 573 TEST CIRCUIT

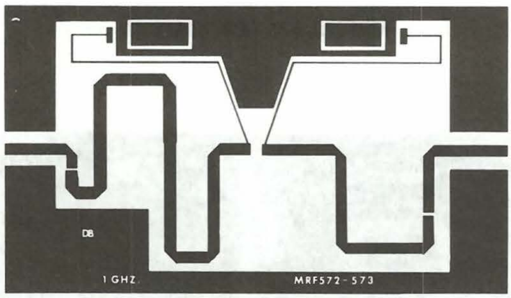


7

PHOTOMASTER OF MRF571 CIRCUIT LAYOUT



PHOTOMASTER OF MRF572, 573 CIRCUIT LAYOUT



MRF580
MRF581

CASE 317A-01, STYLE 2

HIGH FREQUENCY TRANSISTOR

NPN SILICON

CASE 317-01, STYLE 2

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	MRF581	MRF581	Unit
Collector-Emitter Voltage	V_{CEO}	18	18	Vdc
Collector-Base Voltage	V_{CBO}	36	36	Vdc
Emitter-Base Voltage	V_{EBO}	2.5	2.5	Vdc
Collector Current — Continuous	I_C	200	200	mAdc
Total Device Dissipation @ T_C = 50°C(1) Derate above T_C = 50°C	P_D	2.5 25	2.5 25	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150	−65 to +150	°C

(1) Case temperature measured on collector lead immediately adjacent to body of package.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	18	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 mAdc, I_E = 0)		$V_{(BR)CBO}$	36	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.10 mAdc, I_C = 0)		$V_{(BR)EBO}$	2.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)		I_{CBO}	—	—	100	μAdc
Emitter Cutoff Current (V_{CE} = 2.0 Vdc, V_{BE} = 0)		I_{EBO}	—	—	100	μAdc
ON CHARACTERISTICS						
DC Current Gain(1) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)		h_{FE}	50	—	200	—
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 75 mAdc, V_{CE} = 10 Vdc, f = 1.0 GHz)		f_T	—	5.0	—	GHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	—	1.4	2.0	pF
FUNCTIONAL TESTS						
Noise Figure MRF580/581 (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)	Figure 18	NF	—	2.0	3.0	dB
Power Gain at Optimum Noise Figure MRF580 (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)	Figure 18	G_{NF}	11	14	—	dB
Power Gain at Optimum Noise Figure MRF581 (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)	Figure 18	G_{NF}	13	15.5	—	dB
Maximum Available Power Gain MRF580(2) (I_C = 75 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)		G_{max}	—	15	—	dB
Maximum Available Power Gain MRF581(2) (I_C = 75 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)		G_{max}	—	17.5	—	dB
Intermodulation Distortion MRF581(3) (V_{CE} = 10 V, I_C = 75 mA, V_{out} = +50 dBmV)	Figure 16	IMD(d3)	—	−65	—	dB

(1) 300 μs pulse on Tektronix 576 or equivalent.
(2) Characterized on HP8542 Automatic Network Analyzer.
(3) 2 Tones, f1 = 497 MHz, f2 = 503 MHz, 3rd Order Single Tone reference.

FIGURE 1 — C_{ib} INPUT CAPACITANCE versus VOLTAGE

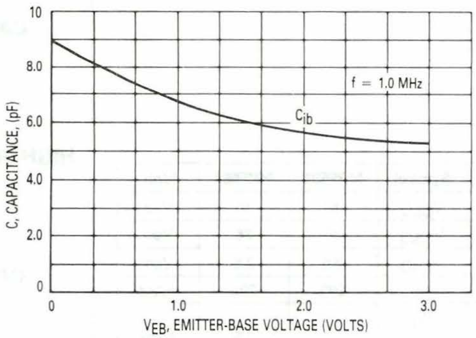


FIGURE 2 — C_{cb}, C_{ob} COLLECTOR-BASE CAPACITANCE versus VOLTAGE

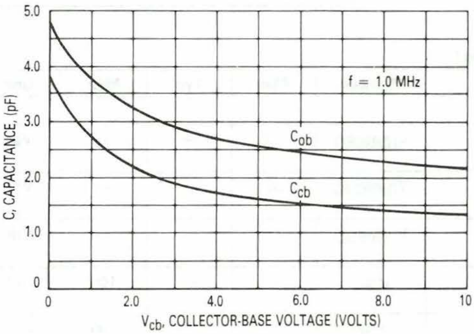
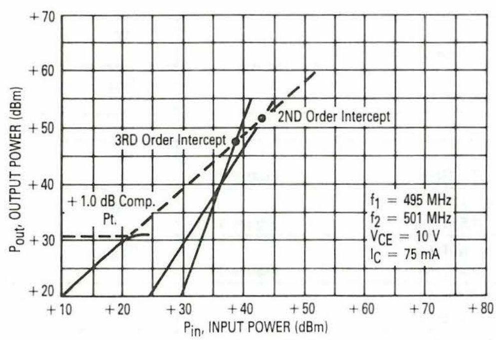


FIGURE 3 — GAIN-BANDWIDTH PRODUCT versus COLLECTOR CURRENT

FIGURE 4 — 2ND AND 3RD ORDER INTERCEPT POINTS



MRF580 TYPICAL PERFORMANCE

FIGURE 5 — $G_{U\ max}$-MAXIMUM UNILATERAL GAIN, $|S_{21}|^2$ versus FREQUENCY

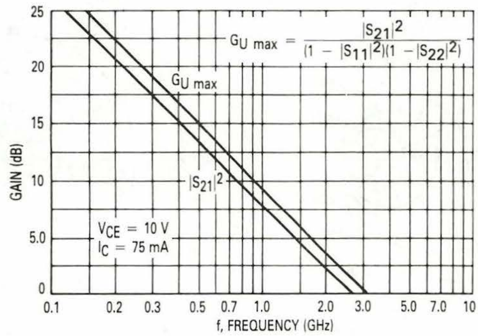


FIGURE 6 — $G_{A\ max}$, MAXIMUM AVAILABLE GAIN versus FREQUENCY

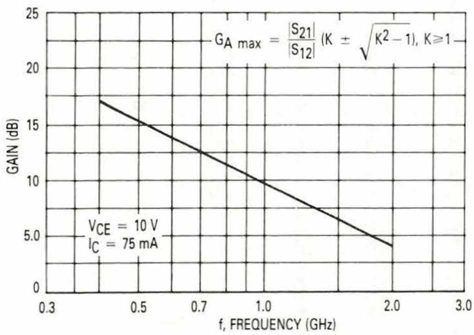


FIGURE 7 — NOISE FIGURE AND GAIN ASSOCIATED WITH NOISE FIGURE versus FREQUENCY

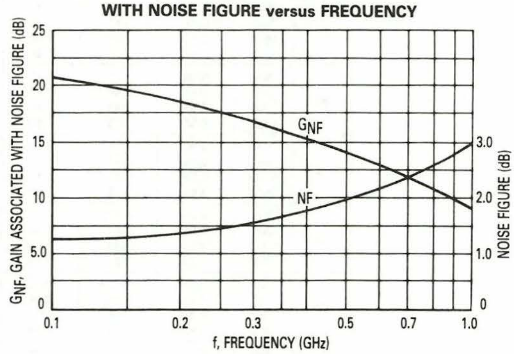


FIGURE 8 — NOISE FIGURE AND GAIN ASSOCIATED WITH NOISE FIGURE versus COLLECTOR CURRENT

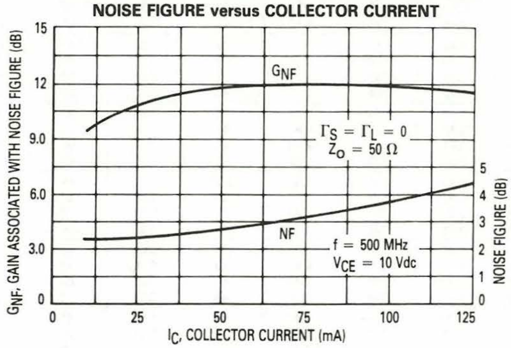
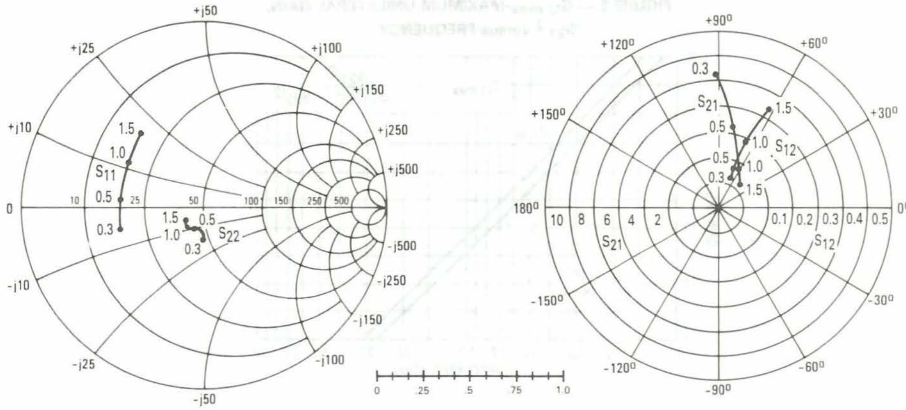


FIGURE 9 — MRF580 COMMON EMITTER S-PARAMETERS

INPUT/OUTPUT REFLECTION COEFFICIENT versus FREQUENCY

V_{CE} = 10 V I_C = 50 mA

FORWARD/REVERSE TRANSMISSION COEFFICIENTS versus FREQUENCY



V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11} $\lvert S_{11}\rvert$	S_{11} $\angle\phi$	S_{21} $\lvert S_{21}\rvert$	S_{21} $\angle\phi$	S_{12} $\lvert S_{12}\rvert$	S_{12} $\angle\phi$	S_{22} $\lvert S_{22}\rvert$	S_{22} $\angle\phi$
5.0	25	300	0.49	−170	5.97	91	0.083	60	0.24	−108
		500	0.52	171	3.63	78	0.127	64	0.18	−117
		1000	0.53	149	1.98	58	0.24	66	0.13	−154
		1500	0.56	125	1.46	44	0.35	60	0.19	−172
	50	300	0.48	−175	6.35	90	0.08	64	0.24	−126
		500	0.51	168	3.85	79	0.13	67	0.18	−139
		1000	0.51	148	2.10	59	0.25	66	0.16	−178
		1500	0.54	123	1.56	46	0.36	58	0.20	169
	75	300	0.48	−177	6.42	90	0.08	65	0.24	−132
		500	0.51	167	3.88	79	0.13	67	0.19	−145
		1000	0.50	147	2.12	59	0.26	65	0.17	175
		1500	0.53	123	1.57	46	0.36	58	0.21	164
	100	300	0.48	−177	6.41	89	0.08	66	0.24	−134
		500	0.51	167	3.87	78	0.13	68	0.19	−148
		1000	0.51	146	2.114	59	0.26	65	0.17	172
		1500	0.53	123	1.58	46	0.36	58	0.21	162
10	25	300	0.44	−164	6.67	92	0.07	61	0.25	−76
		500	0.47	175	4.08	79	0.11	66	0.19	−75
		1000	0.48	152	2.2	60	0.21	68	0.12	−91
		1500	0.52	126	1.56	45	0.32	64	0.15	−129
	50	300	0.47	−167	7.40	91	0.07	65	0.17	−89
		500	0.47	174	4.53	79	0.11	68	0.12	−112
		1000	0.50	149	2.38	62	0.20	67	0.13	−126
		1500	0.53	131	1.71	47	0.31	63	0.11	−147
	75	300	0.41	−171	7.24	91	0.07	66	0.20	−96
		500	0.45	171	4.39	79	0.12	69	0.13	−99
		1000	0.45	150	2.36	61	0.23	67	0.07	−130
		1500	0.48	125	1.72	47	0.33	61	0.12	−157
	100	300	0.42	−172	7.22	90	0.07	67	0.19	−97
		500	0.45	170	4.38	78	0.12	69	0.14	−98
		1000	0.45	149	2.35	60	0.23	67	0.07	−129
		1500	0.49	125	1.71	46	0.33	62	0.11	−158
15	25	300	0.48	−159	7.28	93	0.06	60	0.24	−55
		500	0.48	−179	4.44	80	0.09	66	0.17	−62
		1000	0.51	153	2.33	62	0.18	68	0.19	−82
		1500	0.54	133	1.67	46	0.27	68	0.17	−97
	50	300	0.39	−165	7.49	0.92	0.07	65	0.23	−71
		500	0.42	174	4.57	80	0.11	69	0.18	−67
		1000	0.43	152	2.44	61	0.21	68	0.11	−74
		1500	0.46	126	1.76	47	0.31	64	0.12	−115
	75	300	0.39	−167	7.57	91	0.07	66	0.21	−74
		500	0.42	173	4.57	79	0.11	70	0.17	−69
		1000	0.42	151	2.45	61	0.21	68	0.09	−75
		1500	0.46	126	1.76	46	0.31	64	0.11	−118
	100	300	0.39	−168	7.46	90	0.07	67	0.20	−72
		500	0.43	172	4.53	78	0.11	70	0.17	−66
		1000	0.43	151	2.41	60	0.21	69	0.10	−71
		1500	0.47	126	1.74	46	0.31	64	0.12	−113

7

MRF581 TYPICAL PERFORMANCE

FIGURE 10 — $G_{U\ max}$ — MAXIMUM UNILATERAL GAIN, $|S_{21}|^2$ versus FREQUENCY

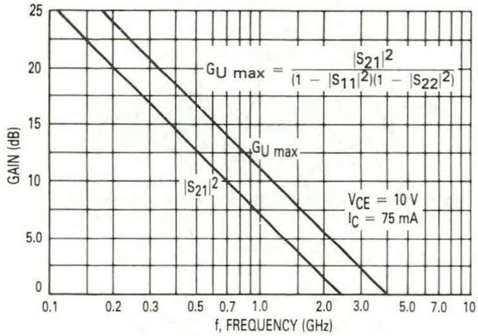


FIGURE 11 — $G_{A\ max}$, MAXIMUM AVAILABLE GAIN versus FREQUENCY

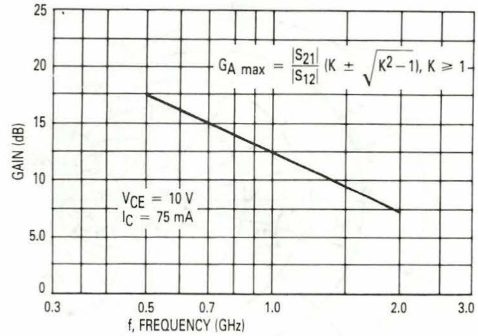


FIGURE 12 — NOISE FIGURE AND GAIN ASSOCIATED WITH NOISE FIGURE versus FREQUENCY

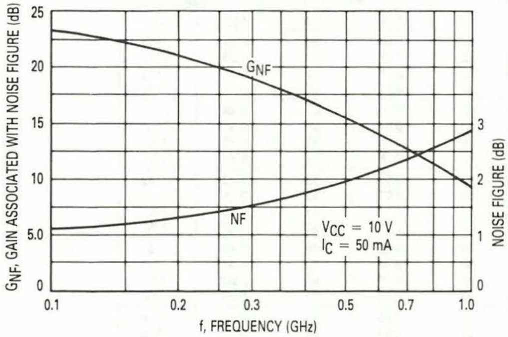


FIGURE 13 — NOISE FIGURE AND GAIN ASSOCIATED WITH NOISE FIGURE versus COLLECTOR CURRENT

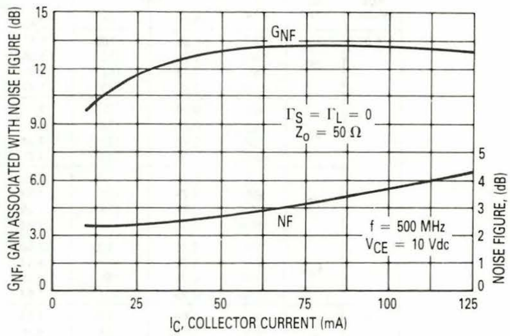


FIGURE 14 — OUTPUT POWER versus INPUT POWER f = 470 MHz

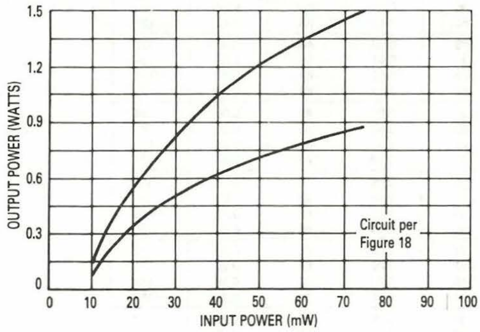
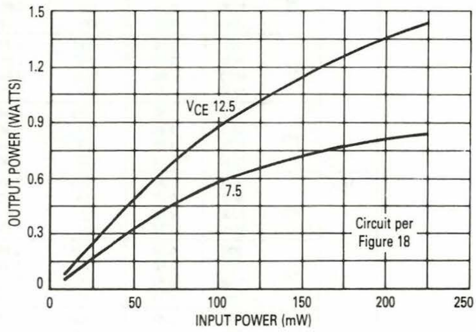


FIGURE 15 — OUTPUT POWER versus INPUT POWER f = 870 MHz

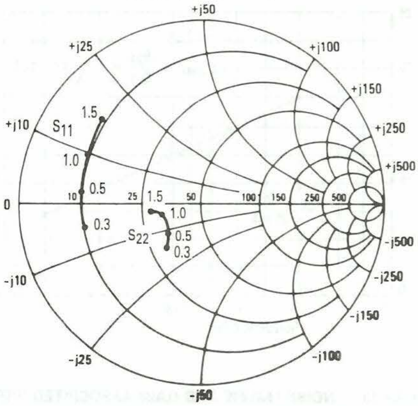


7

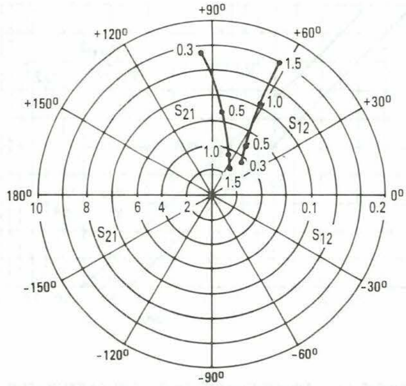
FIGURE 16 — MRF581 COMMON EMITTER S-PARAMETERS

INPUT/OUTPUT REFLECTION COEFFICIENT versus FREQUENCY

V_{CE} = 10 V, I_C = 50 mA

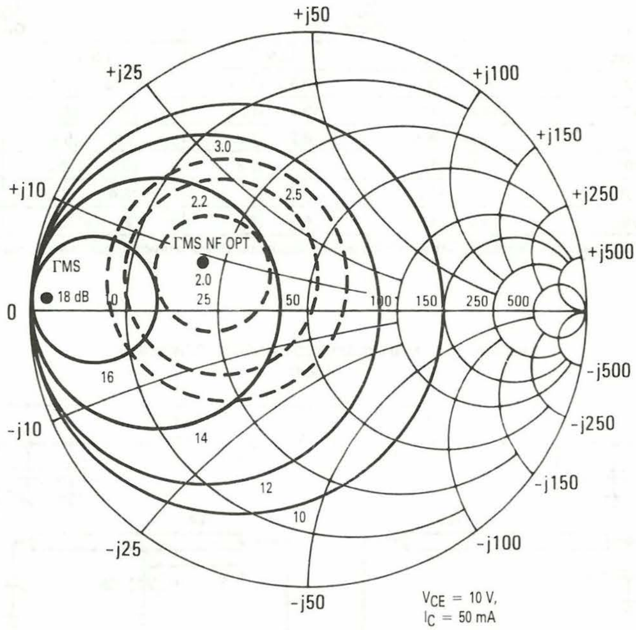


FORWARD/REVERSE TRANSMISSION COEFFICIENTS versus FREQUENCY



V_{CE} (Volts)	I_C (mA)	f (MHz)	S11 $\lvert S_{11}\rvert$	S11 ∠φ	S21 $\lvert S_{21}\rvert$	S21 ∠φ	S12 $\lvert S_{12}\rvert$	S12 ∠φ	S22 $\lvert S_{22}\rvert$	S22 ∠φ
5.0	25	300	0.69	-169	6.57	93	0.06	39	0.34	-129
		500	0.72	176	3.95	82	0.07	47	0.29	-142
		1000	0.73	157	2.10	62	0.12	60	0.27	-165
		1500	0.76	139	1.47	50	0.17	61	0.33	-172
	50	300	0.70	-173	7.14	93	0.05	45	0.38	-144
		500	0.72	173	4.27	82	0.07	53	0.34	-157
		1000	0.72	157	2.24	65	0.13	62	0.33	179
		1500	0.76	138	1.61	53	0.18	61	0.37	173
	75	300	0.70	-175	7.26	92	0.05	48	0.40	-148
		500	0.72	172	4.33	82	0.07	55	0.36	-161
		1000	0.72	155	2.28	65	0.13	63	0.35	176
		1500	0.76	138	1.64	53	0.19	61	0.39	170
	100	300	0.70	-176	7.30	92	0.05	48	0.40	-151
		500	0.72	172	4.34	82	0.07	56	0.37	-163
		1000	0.72	155	2.28	65	0.13	63	0.362	175
		1500	0.75	137	1.64	53	0.19	61	0.39	168
10	25	300	0.66	-165	7.58	95	0.05	40	0.29	-106
		500	0.69	178	4.56	82	0.07	48	0.23	-116
		1000	0.70	159	2.39	64	0.11	61	0.19	-141
		1500	0.74	141	1.65	50	0.16	64	0.26	-153
	50	300	0.65	-169	8.25	94	0.05	46	0.30	-126
		500	0.68	175	4.96	82	0.07	54	0.24	-138
		1000	0.69	157	2.60	65	0.12	63	0.22	-164
		1500	0.72	139	1.82	52	0.17	63	0.27	-171
	75	300	0.66	-171	8.49	93	0.05	48	0.30	-132
		500	0.68	175	5.06	82	0.07	55	0.25	-145
		1000	0.69	157	2.64	65	0.12	64	0.23	-170
		1500	0.72	139	1.86	53	0.17	63	0.27	-176
	100	300	0.66	-172	8.46	93	0.05	49	0.30	-134
		500	0.68	174	5.06	82	0.07	56	0.25	-147
		1000	0.68	157	2.64	65	0.12	64	0.23	-172
		1500	0.72	139	1.86	52	0.17	63	0.27	-177
15	25	300	0.65	-163	7.96	95	0.05	40	0.28	-92
		500	0.67	179	4.82	82	0.06	48	0.21	-98
		1000	0.68	160	2.51	63	0.10	62	0.17	-119
		1500	0.72	141	1.73	49	0.16	65	0.24	-137
	50	300	0.64	-167	8.76	94	0.0	46	0.26	-112
		500	0.66	177	5.37	82	0.06	54	0.20	-122
		1000	0.67	159	2.75	65	0.11	64	0.16	-148
		1500	0.71	141	1.91	51	0.16	64	0.22	-157
	75	300	0.64	-168	8.93	93	0.05	47	0.25	-117
		500	0.66	176	5.34	82	0.06	55	0.20	-128
		1000	0.69	158	2.78	65	0.11	65	0.16	-154
		1500	0.70	140	1.93	51	0.16	64	0.22	-162
	100	300	0.64	-169	8.91	93	0.05	48	0.25	-117
		500	0.66	176	5.33	82	0.6	56	0.19	-129
		1000	0.67	158	2.78	64	0.11	65	0.16	-154
		1500	0.70	140	1.93	51	0.16	64	0.21	-160

FIGURE 17 — MRF581 CONSTANT GAIN CONTOURS NOISE FIGURE CONTOURS



f(MHz)	ΓMS	ΓML	ΓMS NF OPT	G_AMAX (dB)	Rn (Ω)	NF OPT	NF (50 Ω)
500	0.91/176°	0.78/77°	0.39/159°	18	10.5	2.0	2.5

Circuit Per Figure 20

FIGURE 18 — FUNCTIONAL CIRCUIT SCHEMATIC

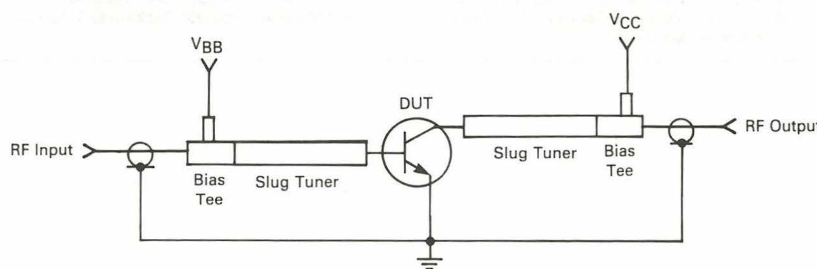
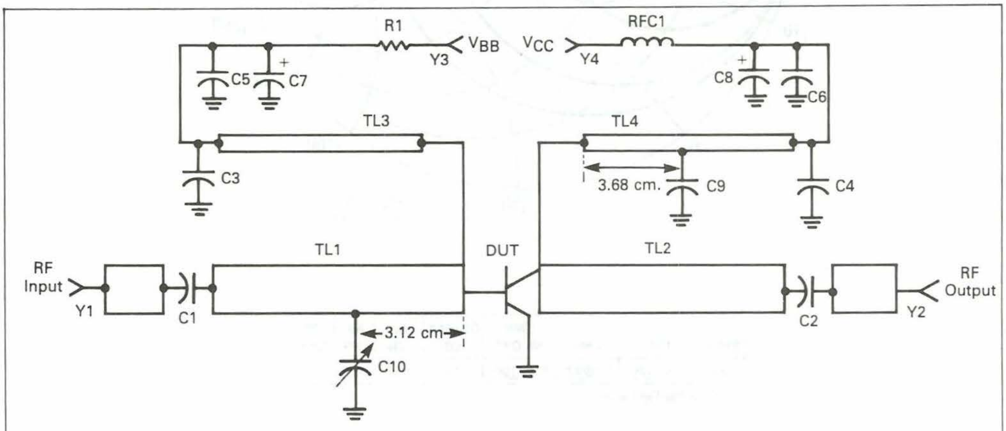


FIGURE 19 — Z_{in} AND Z_{OL} versus COLLECTOR VOLTAGE, INPUT POWER AND FREQUENCY

P_{in} (mW)	f MHz	Z_{in} Ohms		Z_{OL}* Ohms	
		7.5 V	12.5 V	7.5 V	12.5 V
50	420	9.8 − j12.0	10.3 − j11.1	27.5 − j2.7	54.5 + j5.7
	470	14.2 − j11.1	10.2 − j10.2	28.6 − j2.9	30.8 − j26.3
	520	13.6 − j8.6	8.2 − j7.7	27.0 − j5.0	30.4 − j26.0
75	806	7.6 + j1.3	7.7 + j0.8	16.4 − j22.7	22.3 − j34.0
	870	7.7 − j1.7	7.7 − j2.1	18.4 − j19.2	25.1 − j28.1
	960	6.0 + j4.3	5.9 + j2.5	21 − j17.1	24.5 − j20.4

*Z_{OL} = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

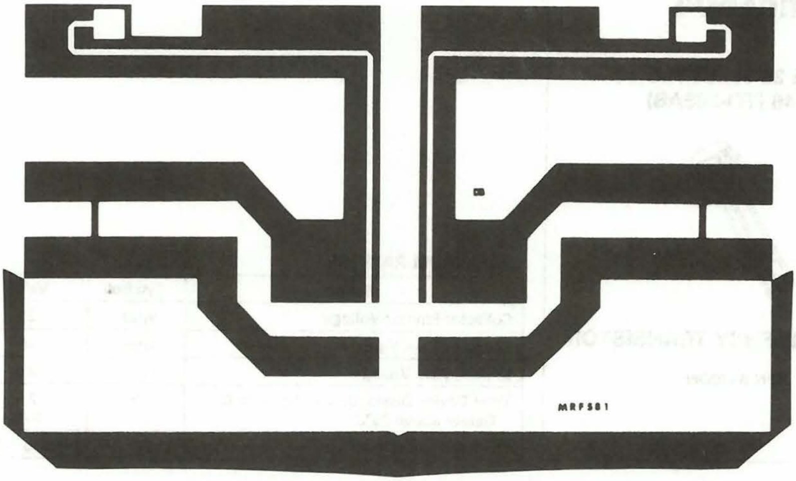
FIGURE 20 — MRF580/581 TEST FIXTURE SCHEMATIC
500 MHz

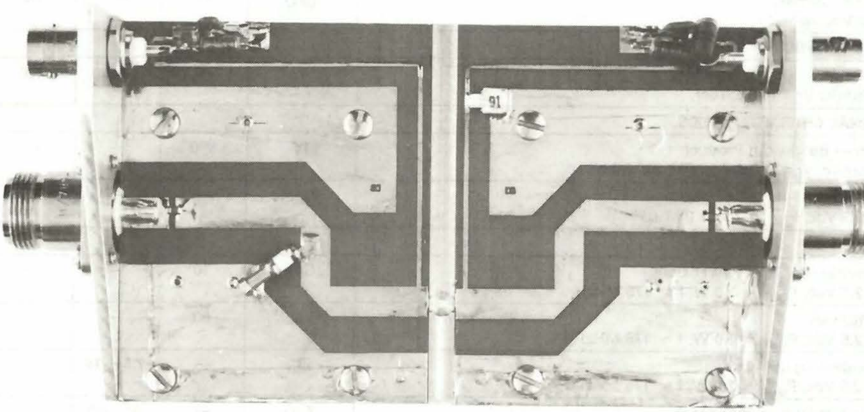


C1, C2 — 470 pF Chip (Ceramic)
C3, C4 — 0.018 μF Chip Capacitor
C5, C6 — 0.1 μF Mylar
C7, C8 — 1.0 μF, 25 Vdc Electrolytic
C9 — 91 pF Mini-Unelco (C9 Taped 3.68 cm from Collector Connection on TL4 as shown)
C10 — 35–45 pF Johanson Ceramic Capacitor, JMC 5801 or Equivalent (C10 Taped 3.12 cm from Base Connection on TL1)

R1 — 2.7 kΩ, 1½ W
RFC1 — 0.15 μH Molded Choke
TL1, TL2 — Z_0 = 26 Ω, 0.0625 TFG as shown in Photomaster
TL3, TL4 — λ/4 Microstrip, Z_0 = 100 Ω
Y1, Y2 — N-Type Connection (Female)
Y3, Y4 — BNC-Type Connector (Female)
Board Material — 0.0625″ Thick Glass Teflon ϵ_r = 2.5

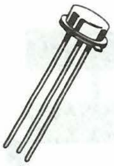
FIGURE 21 — PC BOARD PHOTOMASTER





MRF604

CASE 26-03, STYLE 1
TO-46 (TO-206AB)



HIGH FREQUENCY TRANSISTOR

NPN SILICON

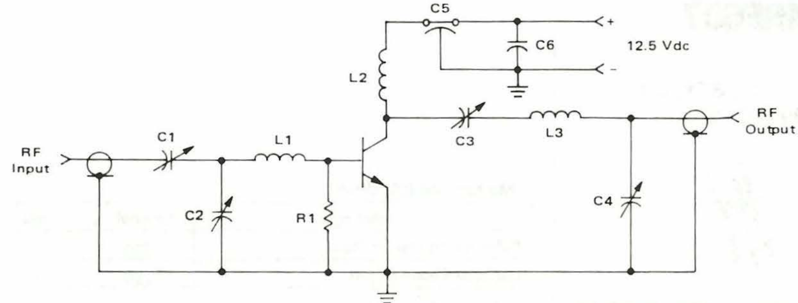
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	2.0	Vdc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	2.5 0.04	Watts W/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 5.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	$V_{(BR)CBO}$	40	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 12$ Vdc, $I_B = 0$)	I_{CEO}	—	—	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 50$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	20	80	200	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 200 MHz)	f_T	800	—	—	MHz
Output Capacitance ($V_{CB} = 12.5$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	—	3.5	pF
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain ($V_{CC} = 12.5$ Vdc, $P_{out} = 1.0$ W, f = 175 MHz)	G_{PE}	10	—	—	dB
Collector Efficiency ($V_{CC} = 12.5$ Vdc, $P_{out} = 1.0$ W, f = 175 MHz)	η	50	—	—	%
Series Equivalent Input Impedance ($V_{CC} = 12.5$ Vdc, $P_{out} = 1.0$ W, f = 175 MHz)	Z_{in}	—	7.5−j14	—	Ohms
Series Equivalent Output Impedance ($V_{CC} = 12.5$ Vdc, $P_{out} = 1.0$ W, f = 175 MHz)	Z_{out}	—	47−j60	—	Ohms

FIGURE 1 – 175 MHz TEST CIRCUIT SCHEMATIC



C1,C2,C3,C4	3.0-30 pF
C5	1000 pF
C6	0.01 μF
L1	2 Turns, #16 AWG, 3/16" I.D., 1/4" Long
L2	0.15 μH, MOLDED CHOKE
L3	4 Turns, #16 AWG, 3/8" I.D., 3/8" Long
R1	100 Ω, 1/4 W, 10%

FIGURE 2 – OUTPUT POWER versus INPUT POWER

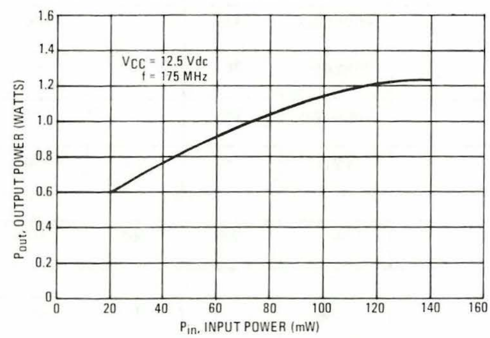


FIGURE 3 – CURRENT-GAIN BANDWIDTH PRODUCT

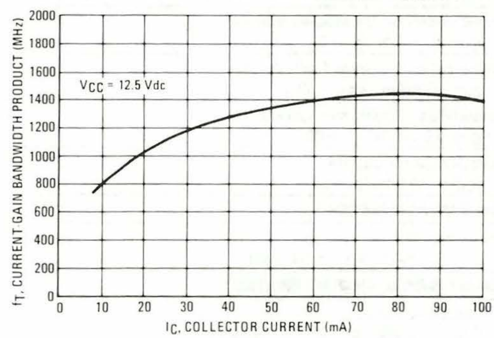
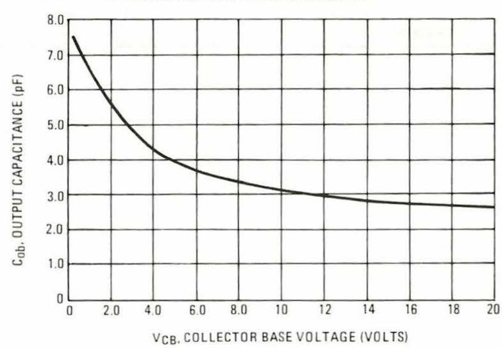


FIGURE 4 – OUTPUT CAPACITANCE versus COLLECTOR BASE VOLTAGE



MRF607

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	16	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	0.33	Adc
Total Device Dissipation @ T_C = 75°C(1) Derate above 75°C	P_D	3.5 28	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

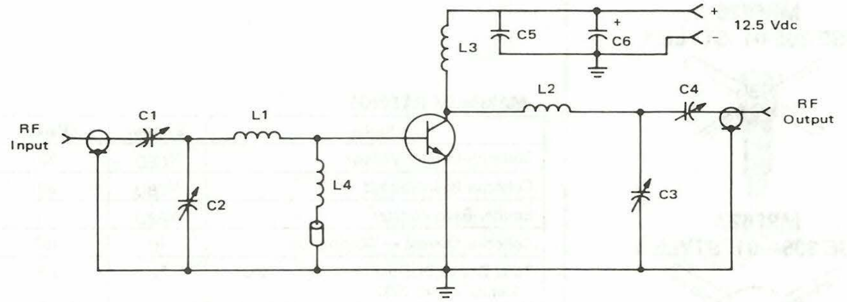
(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as class B or C RF amplifiers.

7

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 25 mAdc, I_B = 0)	$V_{(BR)CEO}$	16	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 25 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.5 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CE} = 10 Vdc, I_B = 0)	I_{CEO}	—	0.3	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	20	150	—
SMALL SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 12 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	15	pF
FUNCTIONAL TEST (FIGURE 1)				
Common-Emitter Amplifier Power Gain (P_{out} = 1.75 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	G_{PE}	11.5	—	dB
Collector Efficiency (P_{out} = 1.75 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	η	50	—	%

FIGURE 1 — 175 MHz TEST CIRCUIT SCHEMATIC



C1	2.7-15 pF, ARCO 461	L1	1 Turn #20 AWG, 3/8" ID
C2	9.0-180 pF, ARCO 463	L2	3 Turns #20 AWG, 3/8" ID
C3,C4	5.0-80 pF, ARCO 462	L3	0.22 μH Molded Choke
C5	1000 pF UNELCO	L4	0.15 μH Molded Choke with FERROXCUBE 56-590-65-3B Bead on ground lead
C6	5 μF, 25 Vdc, TANTALUM		

TYPICAL PERFORMANCE DATA

FIGURE 2 — OUTPUT POWER versus FREQUENCY

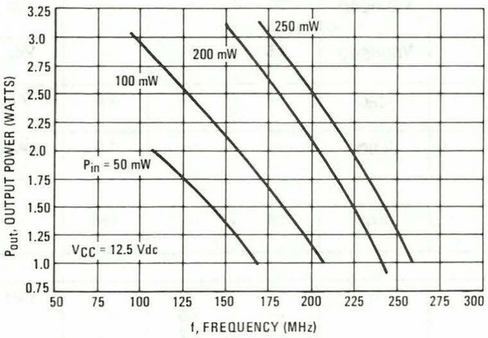


FIGURE 3 — OUTPUT POWER versus INPUT POWER

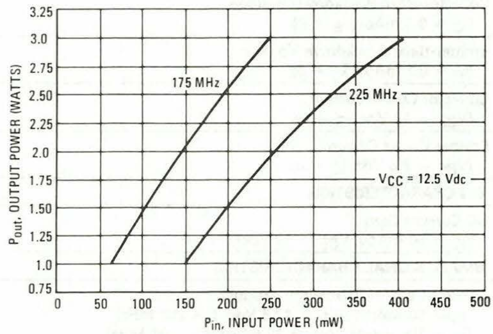


FIGURE 4 — OUTPUT POWER versus SUPPLY VOLTAGE

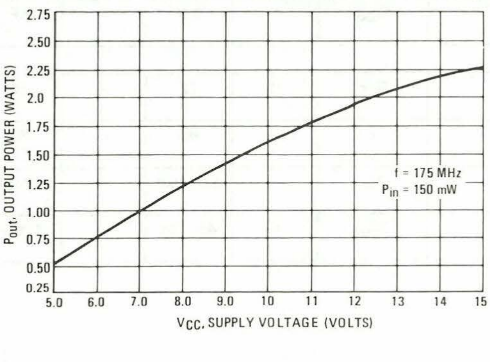
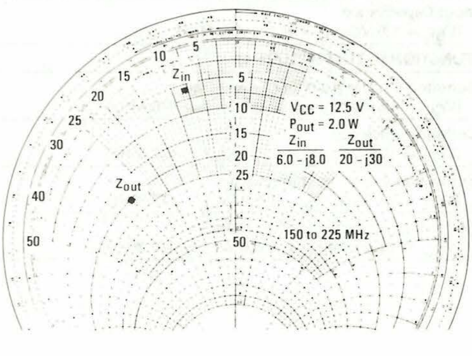
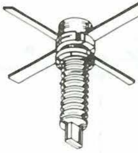


FIGURE 5 — SERIES EQUIVALENT IMPEDANCE PARAMETERS

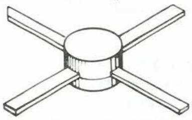


MRF626
MRF627

MRF626
CASE 305-01, STYLE 1



MRF627
CASE 305A-01, STYLE 1



HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	150	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 35	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200°C	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	28.5	°C/W

7

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	30	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CE} = 12 Vdc, I_B = 0)	I_{CEO}	—	—	1.0	mAdc
Emitter Cutoff Current (V_{BE} = 3.5 Vdc, I_C = 0)	I_{EBO}	—	—	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc)	h_{FE}	15	—	150	—
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 12.5 Vdc, f = 200 MHz) (I_C = 100 mAdc, V_{CE} = 12.5 Vdc, f = 200 MHz) (I_C = 150 mAdc, V_{CE} = 12.5 Vdc, f = 200 MHz)	f_T	 — — —	 2.5 2.7 2.6	 — — —	GHz
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	3.0	3.5	pF
Input Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 1.0 MHz)	C_{ibo}	—	8.8	—	pF
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 0.5 W, f = 470 MHz)	G_{PE}	10	12	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 0.5 W, f = 470 MHz)	η	—	60	—	%
Series Equivalent Input Impedance (V_{CC} = 12.5 Vdc, P_{out} = 0.5 W, f = 470 MHz)	Z_{in}	—	6.0−j4.0	—	Ohms
Series Equivalent Output Impedance (V_{CC} = 12.5 Vdc, P_{out} = 0.5 W, f = 470 MHz)	Z_{out}	—	45−j28	—	Ohms

FIGURE 1 – OUTPUT POWER versus INPUT POWER

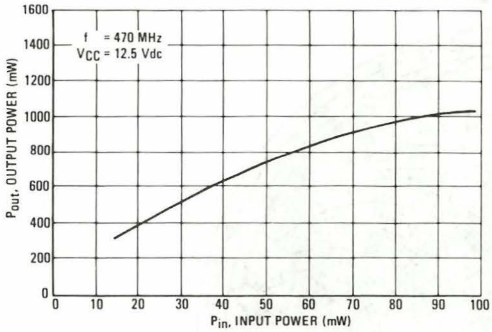


FIGURE 2 – OUTPUT CAPACITANCE versus COLLECTOR BASE VOLTAGE

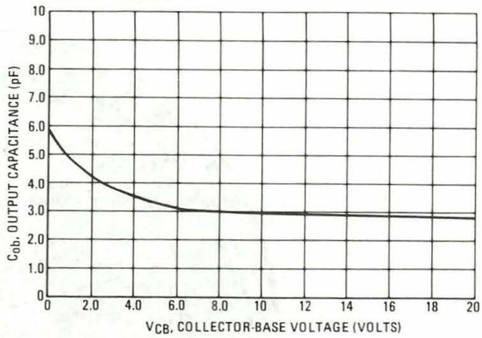
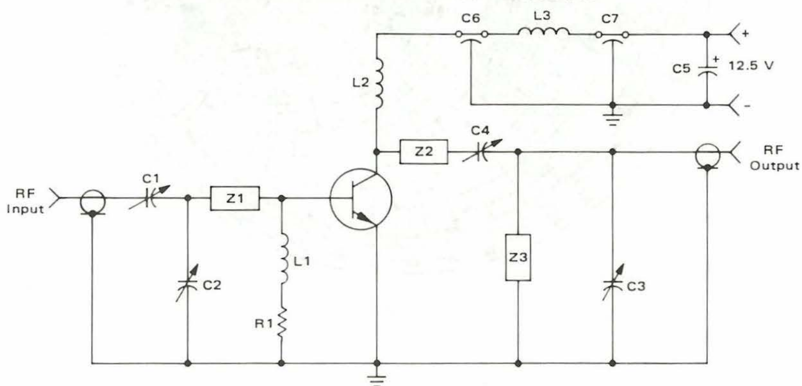


FIGURE 3 – 470 MHz TEST CIRCUIT SCHEMATIC



C1,C2 –	1.0-25 pF ARCO 421	L3 –	Choke FERROXCUBE VK 200-20-4B	Z3 – Microstrip Line, 0.50" W x 1.00" L
C3,C4 –	1.0-25 pF ARCO 421	R1 –	1 Ohm, 1/2 W Carbon	Board-Glass Teflon, 3" x 5" x 0.060"
C5 –	1.0 μF, 35 V Capacitor	Z1 –	Microstrip Line, 0.25" W x 1.75 " L	Mounting Plate is 3" x 5" x 0.75"
C6,C7 –	1000 pF Feedthru	Z2 –	Microstrip Line, 0.25" W x 2.00" L	Input/Output Connectors – Type N
L1,L2 –	7 Turns, #22 AWG, 0.2" I.D.			

FIGURE 4 – 470 MHz TEST CIRCUIT LAYOUT

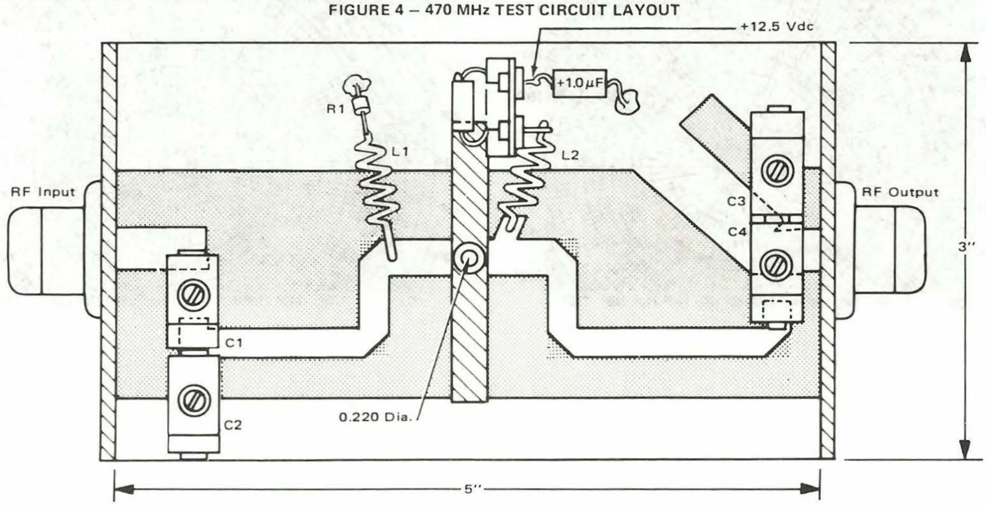


FIGURE 5 – TYPICAL S_{11} and S_{22} versus FREQUENCY

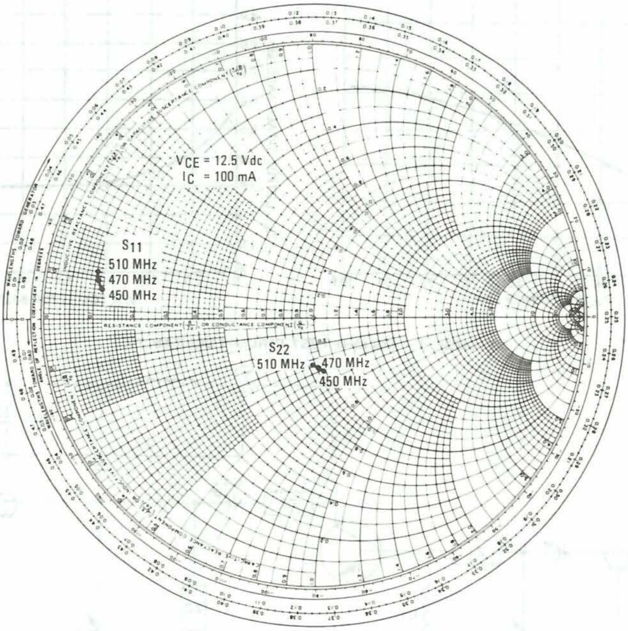


FIGURE 6 – TYPICAL S_{12} versus FREQUENCY

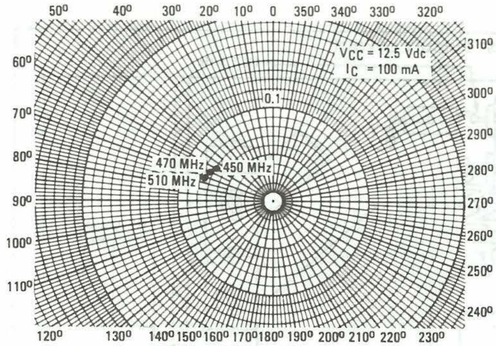
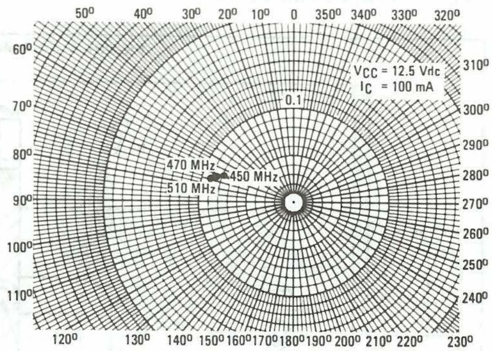
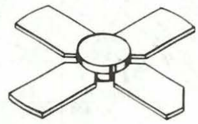


FIGURE 7 – TYPICAL S_{21} versus FREQUENCY



MRF628

CASE 249-05, STYLE 1



UHF AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

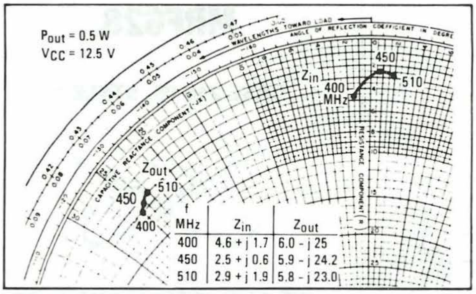
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	16	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	3.0 17.2	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 20$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	16	—	—	Vdc
Collector-Emitter Breakdown Voltage(1) ($I_C = 20$ mAdc, $V_{BE} = 0$)	$V_{(BR)CES}$	36	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 20$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	36	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 5.0$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_C = 0$)	I_{CBO}	—	—	0.5	mAdc
Collector Cutoff Current ($V_{CE} = 15$ Vdc, $V_{BE} = 0$, $T_C = 25°C$)	I_{CES}	—	—	2.0	mAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	20	—	—	—
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance ($V_{CB} = 12$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	6.0	10	pF
FUNCTIONAL TEST (FIGURES 5 AND 6)					
Common-Emitter Amplifier Power Gain ($V_{CC} = 12.5$ Vdc, $P_{out} = 0.5$ W, $I_C(max) = 80$ mAdc, f = 470 MHz)	G_{PE}	10	—	—	dB
Collector Efficiency ($V_{CC} = 12.5$ Vdc, $P_{out} = 0.5$ W, $I_C(max) = 80$ mAdc, f = 470 MHz)	η	50	—	—	%

(1) Pulsed thru 25 mH inductor.

FIGURE 1 – SERIES EQUIVALENT IMPEDANCE PARAMETERS



f MHz	Z_{in}	Z_{out}
400	4.6 + j 1.7	6.0 - j 25
450	2.5 + j 0.6	5.9 - j 24.2
510	2.9 + j 1.9	5.8 - j 23.0

FIGURE 2 – OUTPUT POWER versus INPUT POWER

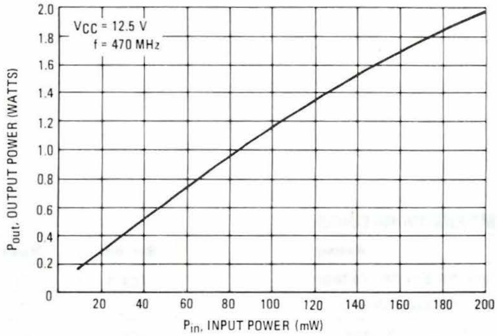


FIGURE 3 – OUTPUT POWER versus FREQUENCY

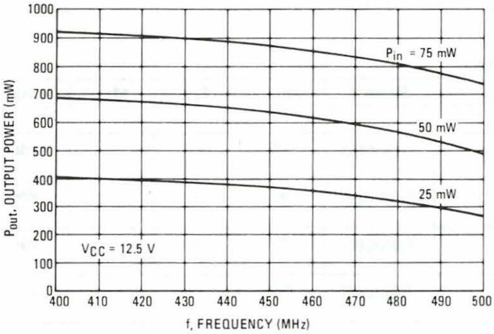
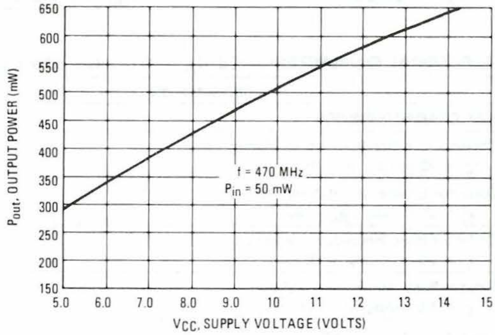


FIGURE 4 – OUTPUT POWER versus VOLTAGE



7

FIGURE 5 – 470 MHz TEST CIRCUIT

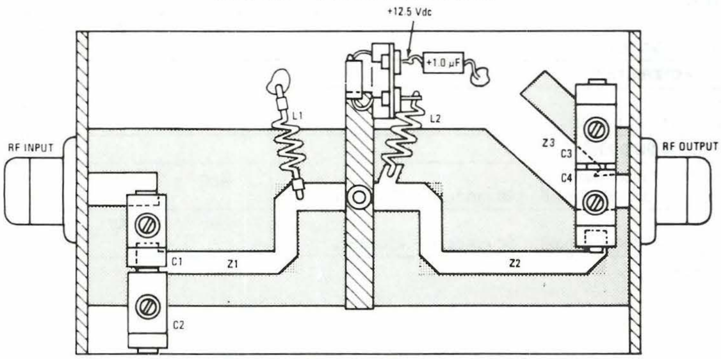
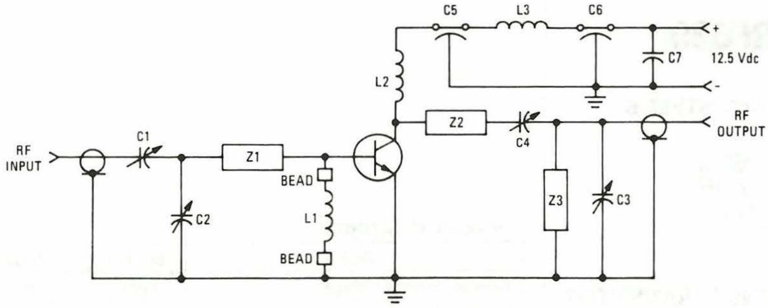


FIGURE 6 – 470 MHz TEST CIRCUIT SCHEMATIC



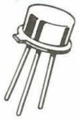
C1,2,3,4	1.0-25 pF ARCO 421 OR EQUIVALENT
C5,6	1000 pF FEEDTHRU CAPACITOR
C7	1.0 μF, 35 V CAPACITOR
L1,2	7 TURNS =22 AWG, 0.2" I.D. FERRITE BEADS FERROXCUBE 56-590-65-3B AS SHOWN ON L1
L3	1-CHOKE FERROXCUBE VK-200-20-4B

BOARD-GLASS TEFLON, ϵ_R = 2.56, t = 0.062
MOUNTING PLATE – 3" x 5" x 0.060"
INPUT/OUTPUT CONNECTORS – TYPE N

7

MRF629

CASE 79-03, STYLE 5



HIGH FREQUENCY TRANSISTOR

NPN SILICON

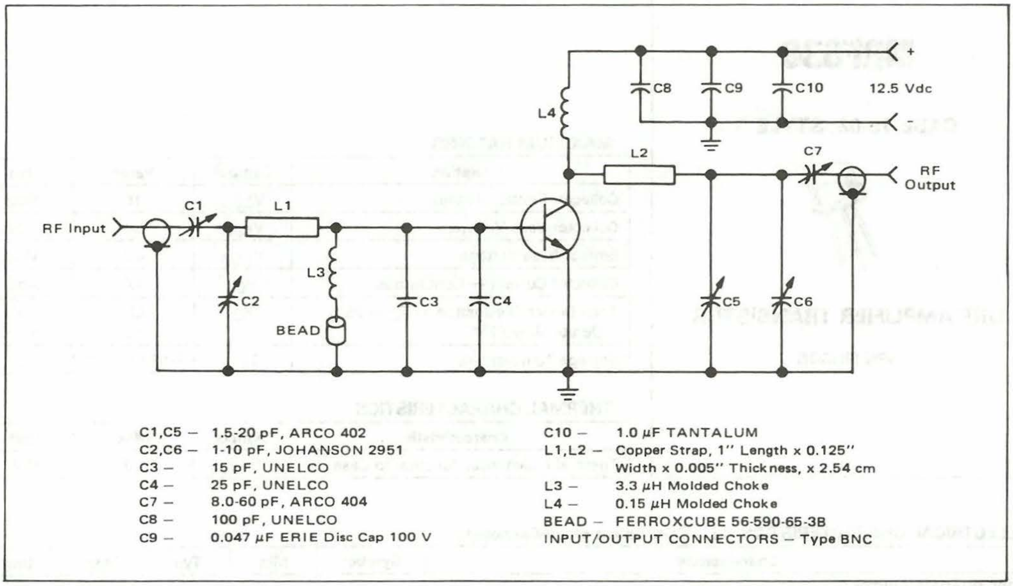
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	16	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	400	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 50	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	$V_{(BR)CEO}$	16	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	20	200	—
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	15	pF
FUNCTIONAL TEST (FIGURE 1)				
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 2.0 W, f = 470 MHz)	G_{PE}	8.0	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 2.0 W, f = 470 MHz)	η	50	—	%

FIGURE 1 — 470 MHz TEST CIRCUIT SCHEMATIC



C1,C5 — 1.5-20 pF, ARCO 402
C2,C6 — 1-10 pF, JOHANSON 2951
C3 — 15 pF, UNELCO
C4 — 25 pF, UNELCO
C7 — 8.0-60 pF, ARCO 404
C8 — 100 pF, UNELCO
C9 — 0.047 μF ERIE Disc Cap 100 V
C10 — 1.0 μF TANTALUM
L1,L2 — Copper Strap, 1" Length x 0.125" Width x 0.005" Thickness, x 2.54 cm
L3 — 3.3 μH Molded Choke
L4 — 0.15 μH Molded Choke
BEAD — FERROXCUBE 56-590-65-3B
INPUT/OUTPUT CONNECTORS — Type BNC

FIGURE 2 — OUTPUT POWER versus INPUT POWER

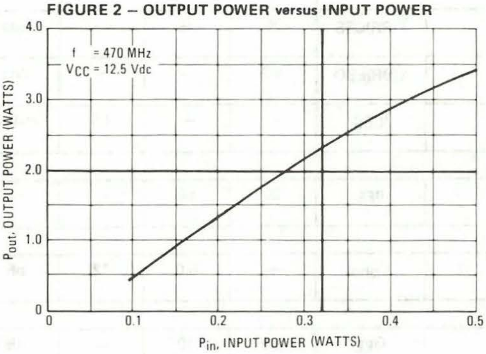


FIGURE 3 — OUTPUT POWER versus FREQUENCY

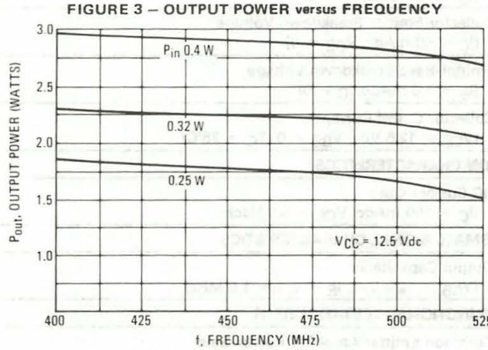


FIGURE 4 — OUTPUT POWER versus SUPPLY VOLTAGE

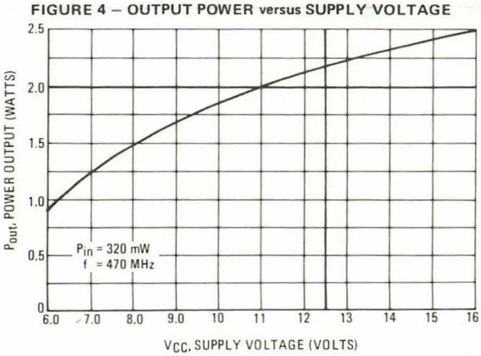
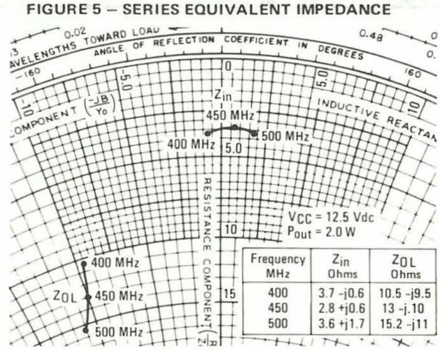


FIGURE 5 — SERIES EQUIVALENT IMPEDANCE



Frequency MHz	Z_{in} Ohms	Z_{OL} Ohms
400	3.7 -j0.6	10.5 -j9.5
450	2.8 +j0.6	13 -j.10
500	3.6 +j1.7	15.2 -j11

MRF630

CASE 79-03, STYLE 5

UHF AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	16	Vdc
Collector-Base Voltage	V_{CES}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	8.75 50	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

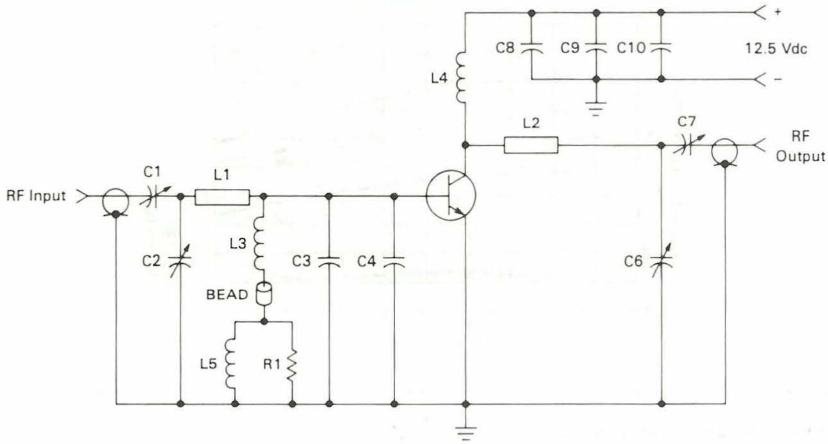
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	20	°C/W

7

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	$V_{(BR)CEO}$	16	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 12.5 Vdc, V_{BE} = 0, T_C = 25°C)	I_{CES}	—	—	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	20	60	—	—
SMALL SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	8.0	12	pF
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 3.0 W, f = 470 MHz)	G_{PE}	9.5	10	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 3.0 W, f = 470 MHz)	η	—	55	—	%

FIGURE 1 — 470 MHz TEST CIRCUIT SCHEMATIC



C1, C7 — 1.5 - 20 pF Johanson
C2, C6 — 1 - 10 pF Johanson
C3, C4 — 27 pF Mini-Unelco
C8 — 250 pF Unelco
C9 — 0.047 μF Erie Disc Cap 10 V
C10 — 1.0 μF Electrolytic

L1, L2 — Copper Strap, 1" Length × 0.225 Width × 0.005" Thickness
L3 — 0.33 μH Molded Choke
L4 — 0.12 μH Molded Choke
L5 — 1.2 μH Molded Choke
R1 — 10 Ω, 1/4 W

FIGURE 2 — OUTPUT POWER versus INPUT POWER

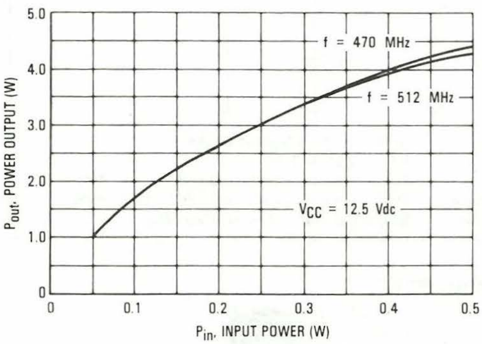


FIGURE 3 — OUTPUT POWER versus FREQUENCY

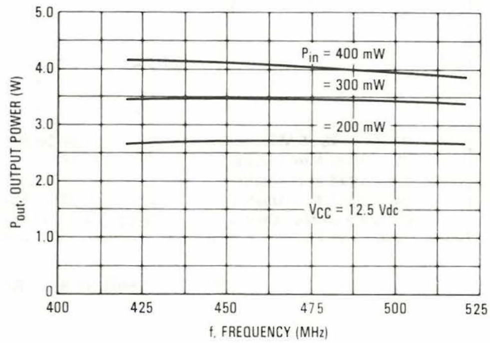


FIGURE 4 — POWER OUT versus SUPPLY VOLTAGE

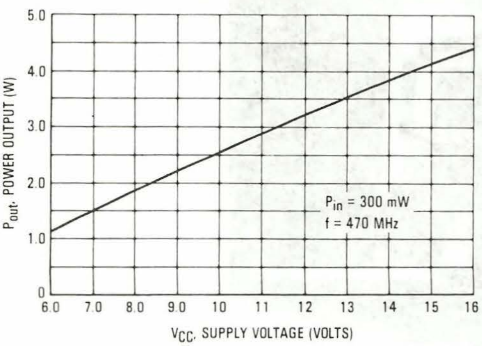
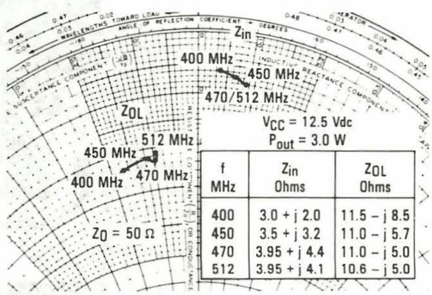


FIGURE 5 — SERIES EQUIVALENT IMPEDANCE



f MHz	Z_{in} Ohms	Z_{OL} Ohms
400	3.0 + j 2.0	11.5 − j 8.5
450	3.5 + j 3.2	11.0 − j 5.7
470	3.95 + j 4.4	11.0 − j 5.0
512	3.95 + j 4.1	10.6 − j 5.0

FIGURE 6 — OUTPUT POWER versus FREQUENCY, BROADBAND CIRCUIT

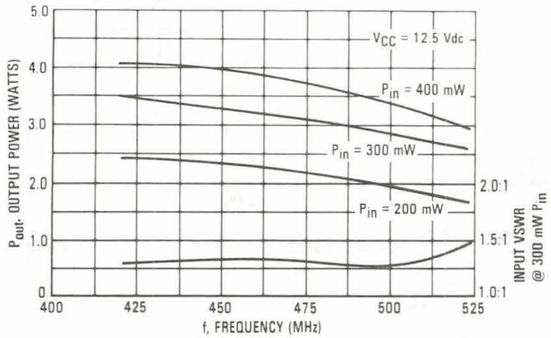
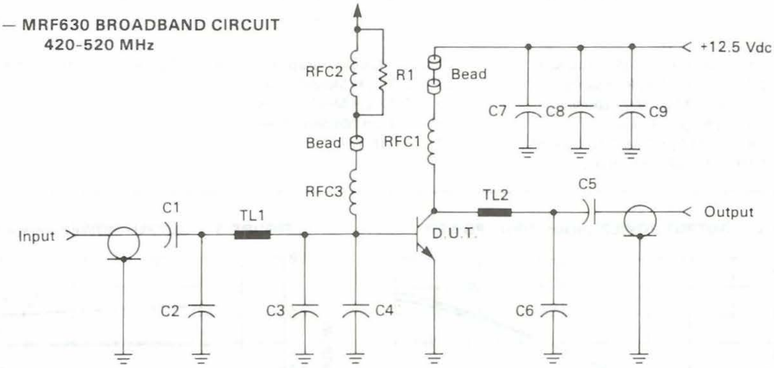
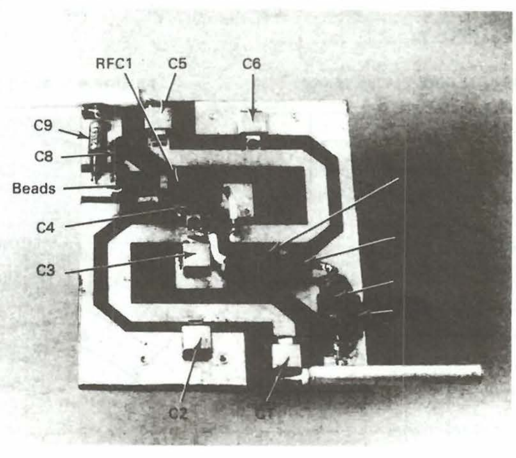


FIGURE 7 — MRF630 BROADBAND CIRCUIT 420-520 MHz



C1, C5 — 43 pF Mini-Unelco
C2 — 10 pF Mini-Unelco
C3 — 18 pF Mini-Unelco
C4 — 27 pF Mini-Unelco
C6 — 6.8 pF Mini-Unelco
C7 — 220 pF Ceramic Chip
C8 — 0.1 mF
C9 — 1.0 mF Tantalum
RFC1 — 0.47 μH Molded Choke
RFC2 — 1.0 μH Molded Choke
RFC3 — 0.3 μH Molded Choke
R1 — 12 Ω/1/4 W
TL1 — Transmission Line 0.166" × 1.85" (WXL)
TL2 — Transmission Line 0.166" × 1.77" (WXL)
Board Material — 2 oz. 0.0625" TFG

FIGURE 8 — BROADBAND CIRCUIT



MRF901

CASE 317-01, STYLE 2

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	30	mAdc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	0.375 3.3	Watt mW/°C
Storage Temperature	T_{stg}	150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	300	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	25	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	2.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	30	80	200	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 15$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 GHz)	f_T	—	4.5	—	GHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	—	0.4	1.0	pF
Noise Figure ($I_C = 5.0$ mAdc, $V_{CE} = 6.0$ Vdc, f = 1.0 GHz)	NF	—	2.0	2.5	dB
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain ($V_{CC} = 6.0$ Vdc, $I_C = 5.0$ mA, f = 1.0 GHz)	G_{pe}	10	12	—	dB
Third Order Intercept ($I_C = 5.0$ mAdc, $V_{CE} = 6.0$ Vdc, f = 0.9 GHz)	—	—	+23	—	dBm

FIGURE 1 — 1.0 GHz TEST CIRCUIT SCHEMATIC

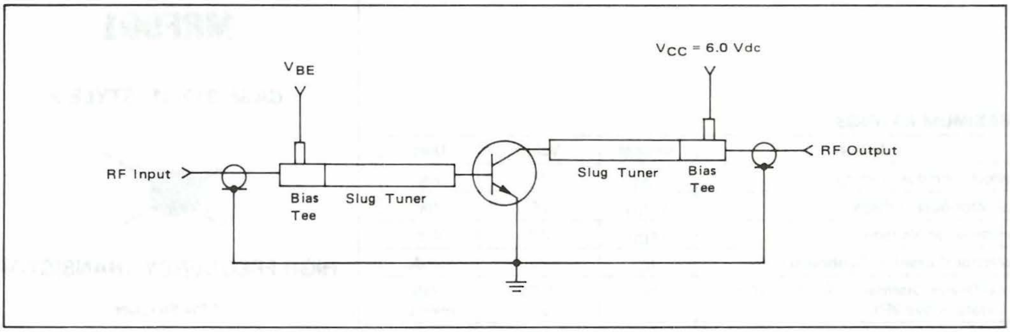


FIGURE 2 — MAXIMUM UNILATERAL GAIN versus FREQUENCY

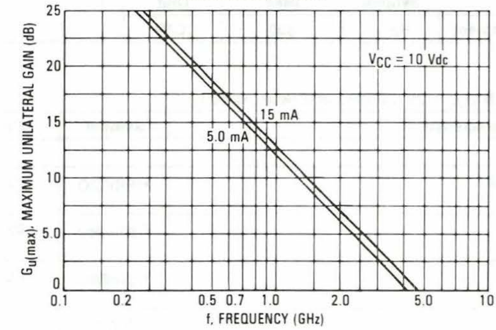


FIGURE 3 — CURRENT-GAIN — BANDWIDTH PRODUCT versus COLLECTOR CURRENT

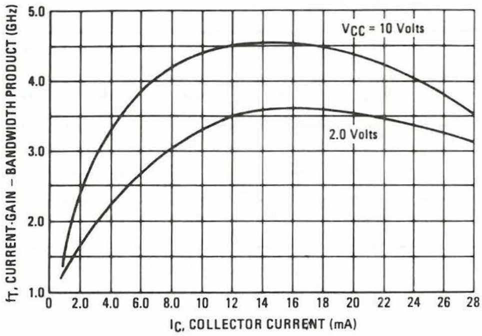


FIGURE 4 — NOISE FIGURE versus FREQUENCY

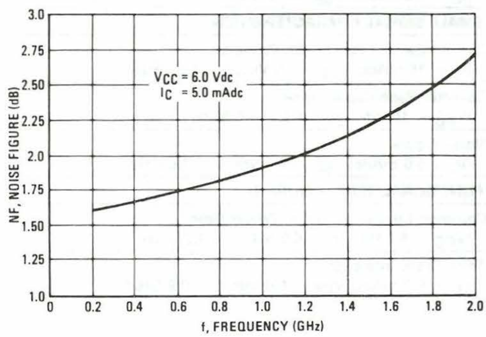


FIGURE 5 — NOISE FIGURE versus COLLECTOR CURRENT

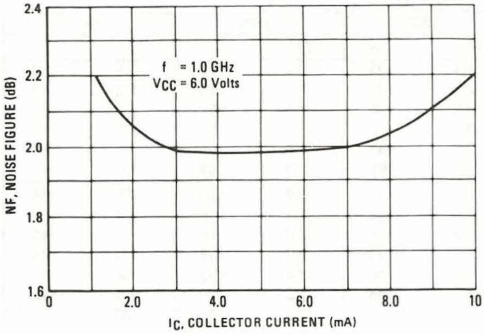


FIGURE 6 — OUTPUT POWER versus INPUT POWER

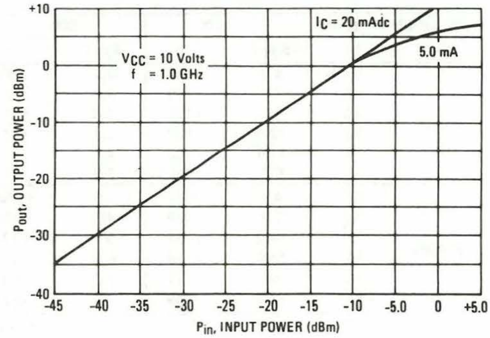


FIGURE 7 — G_{max} versus FREQUENCY

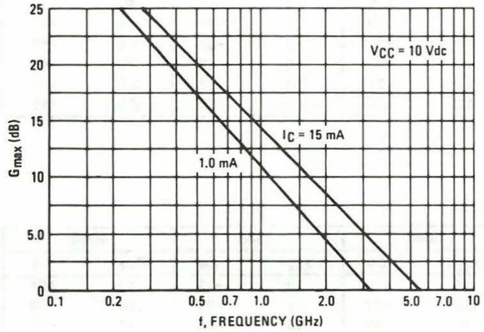


FIGURE 8 — COLLECTOR-BASE CAPACITANCE versus COLLECTOR-BASE VOLTAGE

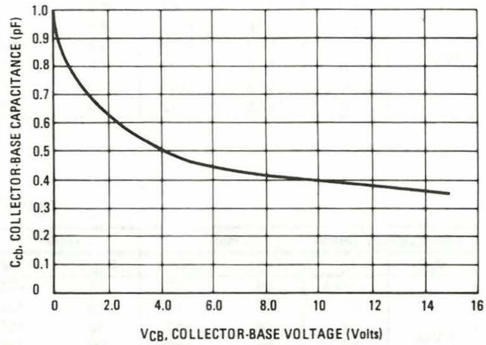


TABLE I — S_{11}

FREQUENCY (MHz)		200		500		1000		1500		2000	
V_{CC}	I_C	$\lvert S_{11} \rvert$	$\angle\phi$	$\lvert S_{11} \rvert$	$\angle\phi$	$\lvert S_{11} \rvert$	$\angle\phi$	$\lvert S_{11} \rvert$	$\angle\phi$	$\lvert S_{11} \rvert$	$\angle\phi$
1 Volt	1.0mA	.83	-54	.65	-110	.61	-153	.62	+177	.65	+157
	2.5	.72	-74	.57	-132	.56	-171	.58	+165	.61	+148
	5.0	.63	-98	.55	-151	.55	+174	.58	+154	.60	+140
	10	.55	-130	.55	-170	.56	+164	.59	+148	.61	+135
	15	.55	-147	.56	-178	.58	+160	.62	+145	.63	+133
	20	.58	-165	.60	+174	.62	+158	.65	+144	.67	+132
3 Volts	1.0	.85	-48	.68	-100	.61	-149	.62	+178	.65	+156
	2.5	.75	-63	.58	-121	.53	-169	.56	+164	.59	+146
	5.0	.64	-82	.52	-139	.51	+177	.54	+156	.57	+139
	10	.53	-112	.48	-160	.51	+167	.54	+149	.56	+134
	15	.49	-126	.48	-168	.52	+162	.55	+145	.57	+132
	20	.48	-137	.49	-173	.53	+160	.56	+145	.58	+131
6 Volts	1.0	.87	-45	.71	-94	.60	-148	.60	+179	.63	+156
	2.5	.77	-58	.60	-114	.52	-164	.55	+168	.57	+148
	5.0	.66	-75	.52	-132	.48	-177	.52	+159	.54	+142
	10	.53	-101	.46	-151	.47	+171	.50	+152	.53	+137
	15	.47	-115	.45	-162	.47	+166	.51	+148	.53	+135
	20	.46	-125	.45	-167	.48	+163	.52	+147	.54	+134
10 Volts	1.0	.88	-43	.72	-91	.60	-145	.60	-178	.63	+158
	2.5	.79	-55	.60	-109	.52	-160	.54	+170	.57	+150
	5.0	.68	-70	.50	-130	.47	-175	.50	+160	.53	+143
	10	.55	-93	.45	-147	.45	+173	.48	+154	.52	+138
	15	.50	-107	.43	-158	.44	+168	.49	+151	.52	+136
	20	.47	-116	.43	-163	.45	+166	.49	+150	.52	+136

TABLE II – S_{21}

FREQUENCY (MHz)		200		500		1000		1500		2000	
V_{CC}	I_C	$\|S_{21}\|$	$\angle\phi$	$\|S_{21}\|$	$\angle\phi$	$\|S_{21}\|$	$\angle\phi$	$\|S_{21}\|$	$\angle\phi$	$\|S_{21}\|$	$\angle\phi$
1 Volt	1.0mA	4.2	+140	2.7	+104	1.4	+73	.96	+52	.77	+39
	2.5	7.2	+130	3.9	+98	2.1	+73	1.4	+55	1.1	+42
	5.0	9.9	+121	4.8	+92	2.6	+72	1.8	+57	1.4	+44
	10	12.0	+109	5.2	+87	2.8	+70	1.9	+57	1.5	+44
	15	11.4	+103	4.9	+84	2.7	+68	1.8	+55	1.4	+42
	20	6.3	+96	2.6	+81	1.9	+65	1.3	+52	1.0	+41
3 Volts	1.0	4.5	+144	3.0	+110	1.5	+78	1.0	+56	.82	+43
	2.5	7.8	+136	4.5	+103	2.5	+76	1.7	+58	1.3	+45
	5.0	11.2	+127	5.7	+97	3.0	+74	2.0	+58	1.6	+45
	10	14.9	+116	6.8	+91	3.4	+72	2.3	+58	1.8	+45
	15	16	+111	7.0	+88	3.6	+70	2.4	+57	1.8	+45
	20	16.4	+108	7.0	+87	3.5	+69	2.4	+56	1.8	+44
6 Volts	1.0	4.5	+146	3.1	+113	1.8	+81	1.2	+60	.96	+46
	2.5	7.8	+139	4.8	+106	2.7	+78	1.8	+60	1.4	+46
	5.0	11.6	+130	6.2	+99	3.3	+75	2.2	+60	1.7	+47
	10	15.9	+120	7.5	+92	3.8	+73	2.5	+59	1.9	+47
	15	17.2	+114	7.7	+90	4.0	+71	2.6	+58	2.0	+46
	20	17.7	+110	7.8	+88	4.0	+70	2.6	+57	2.0	+45
10 Volts	1.0	4.5	+147	3.2	+114	1.8	+82	1.2	+61	.96	+47
	2.5	7.8	+140	4.9	+107	2.7	+79	1.8	+61	1.4	+47
	5.0	11.7	+132	6.4	+100	3.5	+75	2.3	+60	1.8	+48
	10	15.9	+121	7.6	+93	4.0	+73	2.6	+58	2.0	+47
	15	17.4	+115	8.0	+90	4.0	+71	2.7	+57	2.0	+46
	20	17.8	+112	8.0	+88	4.0	+70	2.6	+56	2.0	+45

7

TABLE III – S_{12}

FREQUENCY (MHz)		200		500		1000		1500		2000	
V_{CC}	I_C	$\|S_{12}\|$	$\angle\phi$	$\|S_{12}\|$	$\angle\phi$	$\|S_{12}\|$	$\angle\phi$	$\|S_{12}\|$	$\angle\phi$	$\|S_{12}\|$	$\angle\phi$
1 Volt	1.0mA	.09	+57	.14	+32	.15	+17	.15	+13	.13	+21
	2.5	.08	+49	.10	+32	.12	+27	.13	+32	.14	+40
	5.0	.06	+43	.08	+35	.10	+42	.13	+48	.16	+51
	10	.05	+42	.06	+45	.09	+54	.13	+57	.17	+57
	15	.04	+43	.06	+50	.09	+60	.13	+60	.18	+60
	20	.03	+41	.05	+55	.09	+63	.14	+64	.18	+62
3 Volts	1.0	.06	+61	.10	+37	.13	+21	.12	+20	.10	+31
	2.5	.06	+57	.08	+36	.09	+33	.10	+40	.12	+49
	5.0	.05	+51	.07	+39	.08	+45	.11	+52	.14	+56
	10	.04	+49	.05	+49	.08	+56	.11	+61	.15	+61
	15	.03	+49	.05	+55	.08	+62	.12	+64	.15	+64
	20	.03	+52	.04	+59	.08	+65	.12	+65	.15	+65
6 Volts	1.0	.05	+63	.09	+40	.10	+26	.09	+29	.09	+43
	2.5	.05	+59	.07	+39	.08	+37	.09	+45	.11	+55
	5.0	.04	+55	.05	+42	.07	+48	.09	+56	.12	+62
	10	.03	+50	.04	+51	.07	+58	.10	+64	.13	+66
	15	.02	+53	.04	+55	.07	+64	.10	+67	.13	+68
	20	.03	+54	.04	+60	.07	+66	.10	+69	.13	+69
10 Volts	1.0	.05	+65	.08	+41	.09	+28	.08	+32	.08	+48
	2.5	.04	+59	.06	+42	.07	+38	.08	+48	.09	+59
	5.0	.03	+57	.05	+44	.07	+51	.08	+60	.11	+65
	10	.03	+54	.04	+51	.06	+60	.09	+66	.12	+69
	15	.03	+52	.04	+55	.06	+64	.09	+68	.12	+70
	20	.02	+54	.03	+59	.06	+66	.09	+69	.12	+71

TABLE IV – S_{22}

FREQUENCY (MHz)		200		500		1000		1500		2000	
V_{CC}	I_C	$\lvert S_{22}\rvert$	$\angle\phi$	$\lvert S_{22}\rvert$	$\angle\phi$	$\lvert S_{22}\rvert$	$\angle\phi$	$\lvert S_{22}\rvert$	$\angle\phi$	$\lvert S_{22}\rvert$	$\angle\phi$
1 Volt	1.0mA	.88	-23	.66	-41	.57	-56	.54	-76	.53	-96
	2.5	.76	-34	.48	-50	.40	-61	.37	-78	.37	-98
	5.0	.61	-45	.34	-58	.25	-67	.23	-84	.24	-103
	10	.42	-60	.20	-70	.15	-75	.14	-95	.16	-115
	15	.31	-67	.15	-77	.11	-83	.11	-105	.14	-125
	20	.16	-72	.09	-82	.10	-92	.12	-119	.16	-140
3 Volts	1.0	.91	-18	.75	-32	.66	-47	.62	-65	.60	-82
	2.5	.83	-25	.60	-38	.47	-50	.44	-64	.43	-81
	5.0	.72	-32	.47	-41	.36	-50	.34	-64	.33	-80
	10	.56	-40	.34	-42	.27	-49	.25	-62	.25	-78
	15	.48	-43	.30	-41	.23	-46	.21	-60	.22	-76
	20	.43	-43	.27	-39	.22	-44	.21	-58	.22	-75
6 Volts	1.0	.93	-15	.79	-27	.68	-42	.65	-57	.63	-74
	2.5	.87	-20	.67	-31	.55	-42	.52	-56	.51	-71
	5.0	.77	-26	.55	-34	.45	-41	.43	-53	.42	-68
	10	.63	-32	.43	-33	.37	-38	.36	-50	.35	-64
	15	.57	-33	.40	-31	.35	-35	.34	-47	.33	-62
	20	.53	-33	.38	-29	.34	-34	.33	-46	.33	-61
10 Volts	1.0	.94	-13	.82	-25	.73	-38	.69	-53	.67	-69
	2.5	.89	-18	.70	-28	.60	-38	.57	-51	.56	-66
	5.0	.81	-23	.60	-29	.50	-37	.48	-48	.47	-61
	10	.68	-27	.50	-28	.44	-34	.43	-45	.42	-58
	15	.62	-28	.47	-26	.43	-30	.42	-42	.42	-56
	20	.59	-27	.46	-24	.43	-30	.42	-42	.42	-56

MRF904

CASE 20-03, STYLE 10
TO-72 (TO-206AF)

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	30	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.2 1.14	Watt mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

7

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	25	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	30	—	200	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 15$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 GHz)	f_T	—	4.0	—	GHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	—	—	1.0	pF
Noise Figure ($I_C = 5.0$ mAdc, $V_{CE} = 6.0$ Vdc, f = 450 MHz) ($I_C = 5.0$ mAdc, $V_{CE} = 6.0$ Vdc, f = 1.0 GHz)	NF	 — —	 1.5 2.5	 — —	dB
FUNCTIONAL TEST					
Maximum Available Power(1) ($I_C = 5.0$ mAdc, $V_{CE} = 6.0$ Vdc, f = 450 MHz) ($I_C = 5.0$ mAdc, $V_{CE} = 6.0$ Vdc, f = 1.0 GHz)	G_{max}	 — —	 16 10	 — —	dB

(1) $G_{max} = \frac{|S_{21}|^2}{(1 - |S_{11}|^2)(1 - |S_{22}|^2)}$

FIGURE 1 — NOISE FIGURE versus FREQUENCY

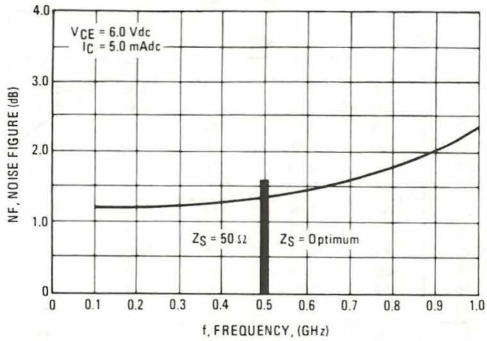


FIGURE 2 — NOISE FIGURE versus COLLECTOR CURRENT

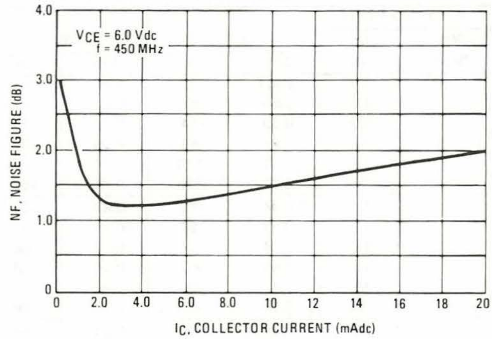


FIGURE 3 — COLLECTOR-BASE CAPACITANCE versus COLLECTOR-BASE VOLTAGE

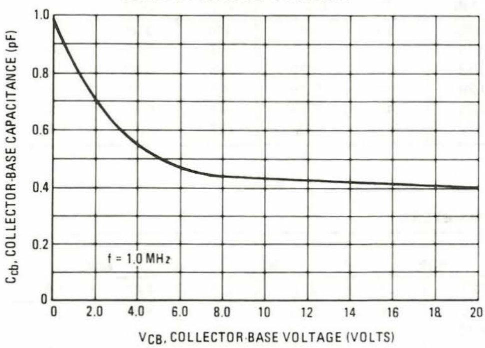


FIGURE 4 — UNILATERALIZED GAIN (G_{max}) versus FREQUENCY

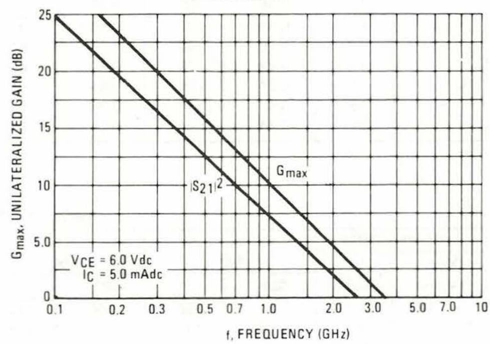


FIGURE 5 — CURRENT-GAIN — BANDWIDTH PRODUCT versus COLLECTOR CURRENT

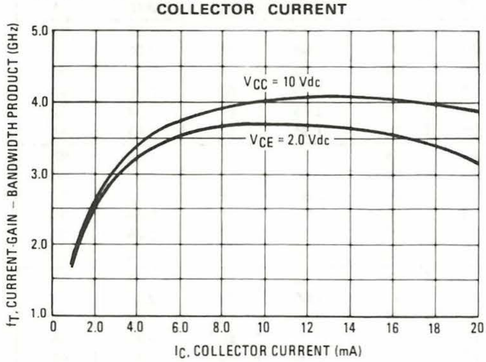
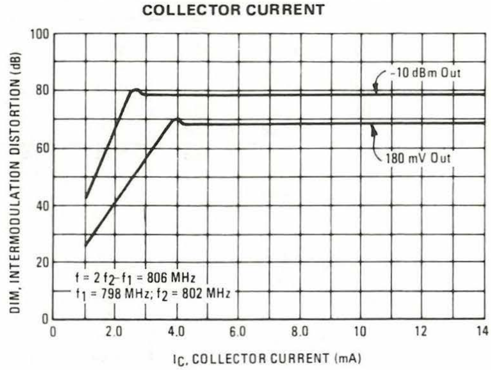


FIGURE 6 — INTERMODULATION DISTORTION versus COLLECTOR CURRENT



7

TABLE 1 – S_{11} PARAMETERS

Frequency (MHz)		100		200		500		800		1000	
V_{CC} (Volts)	I_C (mA)	S11	∠φ	S11	∠φ	S11	∠φ	S11	∠φ	S11	∠φ
1.0	1.0	0.941	-22	0.85	-43	0.57	-91	0.37	-128	0.30	-151
	2.5	0.85	-31	0.67	-57	0.35	-102	0.20	-136	0.14	-157
	5.0	0.69	-44	0.46	-71	0.21	-109	0.10	-144	0.069	-166
	10	0.45	-67	0.28	-94	0.13	-136	0.087	172	0.075	145
	15	0.37	-110	0.31	-145	0.26	170	0.27	139	0.27	122
	30	0.71	-178	0.71	169	0.68	144	0.68	121	0.65	107
3.0	1.0	0.94	-19	0.87	-37	0.61	-80	0.39	-114	0.30	-134
	2.5	0.87	-26	0.71	-47	0.39	-84	0.21	-106	0.15	-115
	5.0	0.74	-34	0.52	-55	0.25	-77	0.13	-82	0.109	-79
	10	0.55	-42	0.35	-58	0.18	-66	0.11	-60	0.105	-55
	15	0.46	-46	0.28	-59	0.15	-64	0.096	-55	0.092	-49
	30	0.28	-95	0.21	-134	0.16	175	0.17	135	0.17	116
6.0	1.0	0.95	-18	0.88	-35	0.63	-76	0.40	-108	0.30	-126
	2.5	0.89	-23	0.74	-43	0.42	-77	0.23	-94	0.17	-100
	5.0	0.77	-31	0.56	-49	0.29	-67	0.18	-69	0.15	-66
	10	0.61	-37	0.40	-50	0.23	-55	0.16	-51	0.16	-50
	15	0.52	-40	0.34	-51	0.20	-52	0.15	-47	0.15	-47
	30	0.36	-55	0.21	-70	0.098	-77	0.037	-59	0.033	-27
10	1.0	0.96	-17	0.89	-33	0.65	-73	0.41	-103	0.31	-121
	2.5	0.89	-22	0.76	-41	0.44	-73	0.25	-88	0.18	-93
	5.0	0.79	-28	0.59	-46	0.32	-63	0.20	-65	0.18	-63
	10	0.64	-34	0.44	-47	0.26	-52	0.19	-49	0.18	-49
	15	0.57	-37	0.38	-48	0.23	-49	0.18	-46	0.17	-46
	30	0.41	-51	0.24	-64	0.12	-67	0.061	-52	0.055	-36

TABLE 2 – S_{21} PARAMETERS

Frequency (MHz)		100		200		500		800		1000	
V_{CC} (Volts)	I_C (mA)	S21	∠φ	S21	∠φ	S21	∠φ	S21	∠φ	S21	∠φ
1.0	1.0	5.32	156	3.06	137	2.22	97	1.65	70	1.44	56
	2.5	6.79	146	5.57	124	3.15	86	2.14	64	1.81	52
	5.0	10.97	133	7.60	110	3.62	79	2.38	61	2.00	49
	10	13.16	118	8.07	99	3.60	74	2.35	57	1.96	46
	15	9.84	108	5.66	91	2.44	67	1.63	49	1.38	38
	30	1.65	83	0.88	69	0.47	46	0.43	37	0.45	31
3.0	1.0	3.33	159	3.11	142	2.36	103	1.79	76	1.55	62
	2.5	6.89	150	5.85	129	3.48	92	2.38	70	2.00	58
	5.0	11.49	138	8.34	115	4.12	84	2.70	66	2.25	55
	10	15.71	125	9.82	104	4.39	79	2.85	63	2.34	53
	15	16.97	119	10.05	100	4.39	77	2.83	61	2.34	52
	30	12.66	108	7.02	92	2.98	70	1.94	54	1.61	44
6.0	1.0	3.31	160	3.10	144	2.41	106	1.83	79	1.60	65
	2.5	6.80	151	5.85	131	3.60	94	2.46	77	2.07	60
	5.0	11.44	140	8.54	117	4.28	86	2.83	68	2.33	57
	10	15.85	127	10.14	107	4.61	81	2.96	65	2.46	55
	15	17.20	122	10.47	102	4.60	79	2.96	63	2.45	54
	30	16.37	113	9.38	96	4.00	75	2.58	59	2.14	49
10	1.0	3.25	160	3.08	145	2.40	108	1.83	81	1.61	67
	2.5	6.73	152	5.85	132	3.63	96	2.50	74	2.10	62
	5.0	11.19	142	8.49	119	4.34	88	2.85	69	2.37	59
	10	15.59	129	10.16	108	4.66	82	3.00	66	2.47	56
	15	17.04	124	10.49	104	4.65	80	2.99	64	2.47	55
	30	16.18	115	9.38	98	4.03	96	2.60	60	2.14	50

TABLE 3 – S_{12} PARAMETERS

Frequency (MHz) V_{CC} (Volts)	I_C (mA)	100 S12	100 ∠φ	200 S12	200 ∠φ	500 S12	500 ∠φ	800 S12	800 ∠φ	1000 S12	1000 ∠φ
1.0	1.0	0.054	73	0.097	61	0.159	41	0.184	36	0.194	37
	2.5	0.051	69	0.084	58	0.140	50	0.189	48	0.220	46
	5.0	0.046	65	0.072	60	0.137	58	0.201	53	0.239	50
	10	0.041	64	0.067	64	0.142	62	0.215	56	0.256	51
	15	0.043	61	0.070	63	0.152	62	0.230	55	0.277	50
	30	0.058	50	0.093	58	0.209	57	0.311	46	0.372	39
3.0	1.0	0.039	75	0.072	65	0.123	46	0.143	42	0.151	44
	2.5	0.037	72	0.063	62	0.110	54	0.150	53	0.174	52
	5.0	0.033	70	0.055	64	0.108	62	0.160	58	0.190	55
	10	0.030	70	0.050	68	0.109	67	0.165	61	0.199	57
	15	0.028	70	0.049	70	0.109	68	0.167	62	0.200	57
	30	0.026	68	0.046	70	0.105	69	0.165	64	0.200	61
6.0	1.0	0.032	76	0.060	66	0.106	49	0.123	45	0.131	48
	2.5	0.031	73	0.054	64	0.095	57	0.130	56	0.151	55
	5.0	0.028	71	0.048	66	0.094	64	0.139	61	0.165	58
	10	0.026	71	0.043	69	0.094	68	0.144	63	0.172	59
	15	0.024	71	0.042	71	0.093	69	0.144	64	0.172	60
	30	0.021	71	0.037	72	0.086	71	0.134	67	0.162	63
10	1.0	0.028	77	0.053	68	0.095	50	0.109	47	0.116	50
	2.5	0.027	74	0.048	65	0.085	58	0.116	57	0.134	57
	5.0	0.025	73	0.043	67	0.084	64	0.125	62	0.148	60
	10	0.023	72	0.037	69	0.084	69	0.128	64	0.153	61
	15	0.022	73	0.037	70	0.084	69	0.128	65	0.152	62
	30	0.019	72	0.033	72	0.076	72	0.119	68	0.143	66

TABLE 4 – S_{22} PARAMETERS

Frequency (MHz) V_{CC} (Volts)	I_C (mA)	100 S22	100 ∠φ	200 S22	200 ∠φ	500 S22	500 ∠φ	800 S22	800 ∠φ	1000 S22	1000 ∠φ
1.0	1.0	0.966	-12	0.893	-23	0.693	-41	0.612	-53	0.594	-59
	2.5	0.901	-18	0.760	-29	0.548	-42	0.498	-51	0.494	-56
	5.0	0.793	-24	0.619	-32	0.456	-39	0.429	-49	0.439	-54
	10	0.635	-29	0.486	-32	0.390	-36	0.377	-47	0.389	-53
	15	0.453	-29	0.364	-29	0.313	-34	0.309	-48	0.321	-14
	30	0.048	-78	0.035	-88	0.032	-135	0.031	-162	0.007	-167
3.0	1.0	0.976	-9.0	0.926	-18	0.770	-35	0.702	-46	0.683	-51
	2.5	0.935	-13	0.828	-23	0.648	-35	0.608	-43	0.608	-48
	5.0	0.853	-18	0.712	-25	0.577	-32	0.555	-41	0.565	-46
	10	0.758	-20	0.629	-23	0.539	-29	0.529	-39	0.544	-44
	15	0.711	-20	0.601	-22	0.533	-27	0.526	-38	0.540	-44
	30	0.631	-15	0.576	-16	0.548	-25	0.546	-38	0.558	-45
6.0	1.0	0.982	-8.0	0.939	-16	0.803	-31	0.742	42	0.734	-47
	2.5	0.947	-11	0.861	-20	0.699	-31	0.662	-40	0.660	-45
	5.0	0.882	-15	0.759	-21	0.633	-29	0.617	-31	0.627	-43
	10	0.801	-17	0.684	-20	0.607	-26	0.601	-35	0.610	-41
	15	0.769	-17	0.667	-19	0.602	-25	0.601	-35	0.607	-40
	30	0.737	-14	0.672	-15	0.640	-22	0.641	-33	0.655	-40
10	1.0	0.983	-7.0	0.949	-14	0.830	-29	0.774	-39	0.765	-40
	2.5	0.954	-10	0.880	-18	0.733	-29	0.698	-37	0.702	-42
	5.0	0.901	-13	0.793	-19	0.676	-27	0.659	-35	0.668	-41
	10	0.834	-15	0.725	-18	0.646	-24	0.646	-33	0.658	-39
	15	0.802	-15	0.706	-17	0.645	-23	0.648	-33	0.661	-39
	30	0.776	-13	0.712	-14	0.678	-22	0.686	-32	0.699	-38

MRF905

CASE 26-03, STYLE 1
TO-46 (TO-206AB)

RF OSCILLATOR TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	35	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	150	mAdc
Total Device Dissipation @ T_C = 100°C Derate above 100°C	P_D	2.5 40	Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

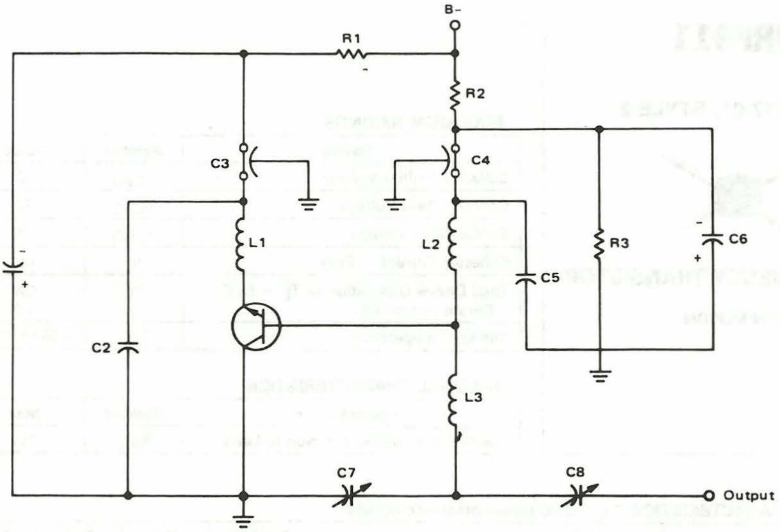
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	25	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	30	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	35	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.5	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	—	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	60	150	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 200 MHz)	f_T	—	2500	—	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	3.0	5.0	pF
FUNCTIONAL TEST					
Common-Collector Oscillator Output Power (Figure 1) (V_E = −20 Vdc, I_E ≅ 110 mAdc, f ≅ 1.68 GHz)	P_{out}	400	500	—	mW

FIGURE 1 – 1.68 GHz OSCILLATOR TEST CIRCUIT SCHEMATIC



C1,C6	1.0 μF, 35 Vdc TANTALUM	R1	47 Ohms, 1/4 Watt
C2,C5	0.1 μF Ceramic Disk	R2	510 Ohms, 1/4 Watt
C3,C4	680 pF Feedthru	R3	1.5 kΩ, 1/4 Watt
C7,C8	0.4-6.0 pF JOHANSON	L1,L2	5 Turns, #22 AWG, 0.125" I.D.
		L3	#20 AWG, 0.4" Length.

7

MRF911

CASE 317-01, STYLE 2

HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Peak	I_C	40	mAdc
Total Device Dissipation @ $T_L = 50°C$ Derate above 50°C	P_D	400 4.0	mW mW/°C
Storage Temperature	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Lead	$R_{\theta JL}$	250	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	12	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	30	—	200	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 GHz)	f_T	—	5.0	—	GHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	—	0.6	1.0	pF
FUNCTIONAL TEST					
Noise Figure ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 GHz) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 2.0 GHz)	NF	 — —	 2.5 4.0	 — —	dB
Power Gain at Optimum Noise Figure ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 GHz) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 2.0 GHz)	G_{NF}	 — —	 10 6.0	 — —	dB
Maximum Available Power Gain(1) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 GHz) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc, f = 2.0 GHz)	G_{max}	 — —	 12.5 7.5	 — —	dB

(1) $G_{max} = \dfrac{|S_{21}|^2}{(1 - |S_{11}|^2)(1 - |S_{22}|^2)}$

7

FIGURE 1 – POWER DERATING

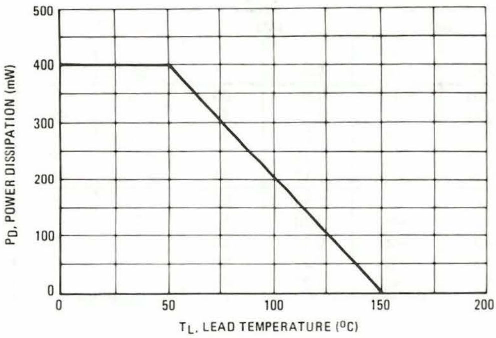


FIGURE 2 – POWER GAIN AND NOISE FIGURE versus FREQUENCY

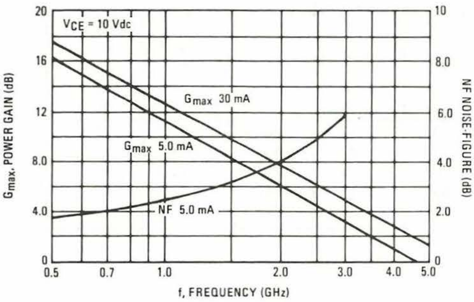


FIGURE 3 – POWER GAIN AND NOISE FIGURE versus COLLECTOR CURRENT

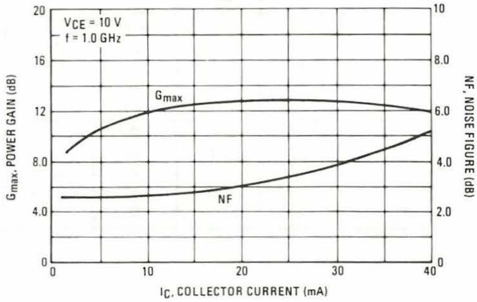


FIGURE 4 – S_{11} PARAMETERS

Frequency (MHz)		500		1000		1500		2000	
V_{CE} (Volts)	I_C (mA)	S11	∠φ	S11	∠φ	S11	∠φ	S11	∠φ
5.0	2.0	0.66	-125	0.64	-175	0.68	160	0.73	140
	5.0	0.57	-150	0.58	170	0.62	150	0.66	135
	10	0.54	-165	0.57	160	0.60	145	0.64	130
	20	0.54	-180	0.57	155	0.60	140	0.64	125
	30	0.54	175	0.57	155	0.61	140	0.65	125
10	2.0	0.66	-120	0.63	-170	0.67	160	0.71	140
	5.0	0.56	-145	0.56	175	0.60	150	0.64	135
	10	0.51	-160	0.53	165	0.57	145	0.61	130
	20	0.49	-175	0.52	160	0.57	145	0.60	130
	30	0.49	-175	0.53	160	0.57	145	0.61	130

FIGURE 5 – S_{22} PARAMETERS

Frequency (MHz)		500		1000		1500		2000	
V_{CE} (Volts)	I_C (mA)	S22	∠φ	S22	∠φ	S22	∠φ	S22	∠φ
5.0	2.0	0.61	-45	0.50	-60	0.48	-80	0.50	-100
	5.0	0.40	-55	0.31	-65	0.30	-85	0.32	-100
	10	0.27	-60	0.20	-70	0.20	-90	0.23	-105
	20	0.19	-70	0.13	-75	0.14	-95	0.17	-110
	30	0.16	-70	0.11	-75	0.13	-95	0.16	-110
10	2.0	0.66	-35	0.55	-50	0.53	-70	0.54	-90
	5.0	0.47	-45	0.38	-50	0.37	-70	0.38	-75
	10	0.35	-45	0.28	-50	0.27	-65	0.29	-85
	20	0.26	-45	0.22	-50	0.22	-65	0.24	-80
	30	0.25	-40	0.21	-45	0.22	-60	0.24	-80

FIGURE 6 – S_{21} PARAMETERS

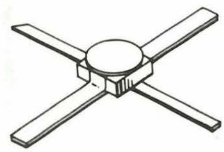
Frequency (MHz)		500		1000		1500		2000	
V_{CE} (Volts)	I_C (mA)	S21	∠φ	S21	∠φ	S21	∠φ	S21	∠φ
5.0	2.0	3.24	100	1.84	70	1.23	50	0.96	35
	5.0	4.85	90	2.60	70	1.76	50	1.38	40
	10	5.78	85	3.04	70	2.05	50	1.61	40
	20	6.40	85	3.30	65	2.23	50	1.24	40
	30	6.47	80	3.35	65	2.26	50	1.76	40
10	2.0	3.42	100	1.95	70	1.31	50	1.01	35
	5.0	5.20	95	2.80	70	1.89	50	1.45	40
	10	6.22	90	3.28	70	2.20	55	1.71	40
	20	6.82	85	3.55	65	2.37	55	1.84	40
	30	6.90	85	3.55	65	2.36	50	1.81	40

FIGURE 7 – S_{12} PARAMETERS

Frequency (MHz)		500		1000		1500		2000	
V_{CE} (Volts)	I_C (mA)	S12	∠φ	S12	∠φ	S12	∠φ	S12	∠φ
5.0	2.0	0.11	30	0.12	25	0.11	35	0.13	50
	5.0	0.08	40	0.10	45	0.13	55	0.17	55
	10	0.07	50	0.10	55	0.14	60	0.19	60
	20	0.06	60	0.11	65	0.15	65	0.20	60
	30	0.06	65	0.11	65	0.15	65	0.20	60
10	2.0	0.10	35	0.10	30	0.10	40	0.12	55
	5.0	0.07	40	0.09	45	0.12	55	0.15	60
	10	0.06	50	0.09	55	0.13	60	0.17	60
	20	0.06	60	0.10	65	0.13	65	0.18	60
	30	0.06	60	0.10	65	0.14	65	0.18	65

MRF912

CASE 303-01, STYLE 1



HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Peak	I_C	50	mAdc
Total Device Dissipation @ T_C = 75°C Derate above 75°C	P_D	500 4.0	mW mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	250	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	12	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 30 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30	—	200	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 30 mAdc, V_{CE} = 10 Vdc, f = 1.0 GHz)	f_T	—	5.0	—	GHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	0.6	1.0	pF
FUNCTIONAL TEST					
Noise Figure (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 GHz) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 2.0 GHz)	NF	 — —	 2.5 4.0	 3.0 —	dB
Power Gain at Optimum Noise Figure (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 GHz) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 2.0 GHz)	G_{NF}	 — —	 12 7.0	 — —	dB
Maximum Available Power Gain(1) (I_C = 30 mAdc, V_{CE} = 10 Vdc, f = 1.0 GHz) (I_C = 30 mAdc, V_{CE} = 10 Vdc, f = 2.0 GHz)	G_{max}	 14 —	 16.5 11.0	 — —	dB

(1) $G_{max} = \frac{|S_{21}|^2}{(1 - |S_{11}|^2)(1 - |S_{22}|^2)}$

7

FIGURE 1 – POWER DERATING

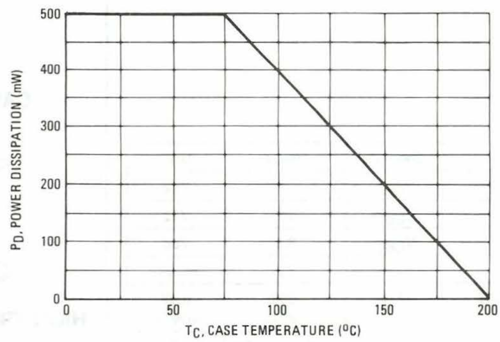


FIGURE 2 – POWER GAIN AND NOISE FIGURE versus FREQUENCY

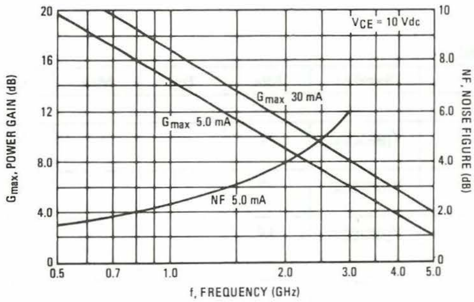


FIGURE 3 – POWER GAIN AND NOISE FIGURE versus COLLECTOR CURRENT

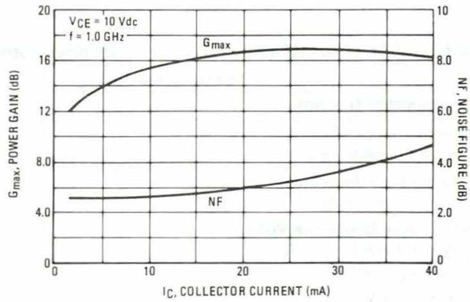


FIGURE 4 – S_{11} PARAMETERS

Frequency (MHz)		500		1000		1500		2000	
V_{CE} (Volts)	I_C (mA)	S11	∠φ	S11	∠φ	S11	∠φ	S11	∠φ
5.0	2.0	0.76	-120	0.74	-160	0.76	-175	0.79	175
	5.0	0.72	-145	0.73	-170	0.75	175	0.77	165
	10	0.71	-160	0.74	180	0.75	170	0.77	160
	20	0.73	-170	0.75	175	0.77	165	0.79	155
	30	0.74	-175	0.76	170	0.78	165	0.81	155
	40	0.74	-180	0.76	165	0.79	155	0.81	145
	50	0.74	180	0.77	165	0.79	155	0.82	145
10	2.0	0.77	-115	0.74	-155	0.76	-170	0.78	175
	5.0	0.71	-140	0.72	-170	0.73	175	0.75	165
	10	0.69	-155	0.71	-175	0.73	170	0.75	165
	20	0.69	-165	0.72	175	0.74	165	0.76	160
	30	0.70	-170	0.73	175	0.75	165	0.77	160
	40	0.69	-175	0.72	165	0.75	155	0.78	145
	50	0.70	-175	0.73	165	0.76	155	0.80	145

FIGURE 5 — S_{22} PARAMETERS

Frequency (MHz)		500		1000		1500		2000	
V_{CE} (Volts)	I_C (mA)	S22	∠φ	S22	∠φ	S22	∠φ	S22	∠φ
5.0	2.0	0.66	-50	0.57	-70	0.57	-95	0.61	-115
	5.0	0.45	-65	0.37	-85	0.39	-105	0.44	-120
	10	0.33	-80	0.27	-100	0.30	-115	0.35	-130
	20	0.24	-95	0.21	-115	0.24	-125	0.29	-135
	30	0.21	-100	0.18	-120	0.22	-125	0.28	-135
	40	0.18	-100	0.16	-115	0.20	-125	0.27	-135
	50	0.17	-95	0.16	-110	0.21	-120	0.28	-135
10	2.0	0.71	-45	0.62	-65	0.62	-85	0.64	-105
	5.0	0.51	-55	0.43	-70	0.44	-90	0.48	-105
	10	0.37	-60	0.31	-75	0.33	-95	0.38	-110
	20	0.27	-70	0.23	-80	0.26	-95	0.32	-115
	30	0.23	-65	0.21	-80	0.25	-95	0.31	-110
	40	0.23	-60	0.22	-70	0.25	-90	0.32	-110
	50	0.24	-50	0.24	-65	0.28	-90	0.34	-105

FIGURE 6 — S_{21} PARAMETERS

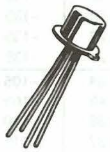
Frequency (MHz)		500		1000		1500		2000	
V_{CE} (Volts)	I_C (mA)	S21	∠φ	S21	∠φ	S21	∠φ	S21	∠φ
5.0	2.0	3.52	102	1.97	70	1.33	50	0.99	35
	5.0	5.61	95	2.96	70	1.98	50	1.50	35
	10	6.84	90	3.55	70	2.35	55	1.78	40
	20	7.65	85	3.94	65	2.59	50	1.96	40
	30	7.93	85	4.02	65	2.63	50	1.98	40
	40	7.87	80	3.95	65	2.57	45	1.92	30
	50	7.65	80	3.86	60	2.48	45	1.86	30
10	2.0	3.70	105	2.12	75	1.43	50	1.07	35
	5.0	6.09	95	3.24	70	2.17	50	1.62	35
	10	7.53	90	3.91	70	2.58	55	1.96	40
	20	8.54	85	4.38	70	2.86	55	2.17	40
	30	8.79	85	4.45	65	2.92	50	2.17	40
	40	8.58	80	4.32	65	2.80	45	2.08	30
	50	8.30	80	4.15	60	2.69	45	1.98	30

FIGURE 7 — S_{12} PARAMETERS

Frequency (MHz)		500		1000		1500		2000	
V_{CE} (Volts)	I_C (mA)	S12	∠φ	S12	∠φ	S12	∠φ	S12	∠φ
5.0	2.0	0.11	25	0.11	5.0	0.10	-5	0.09	-5
	5.0	0.07	25	0.08	15	0.08	15	0.08	15
	10	0.05	25	0.06	25	0.07	30	0.08	30
	20	0.04	35	0.05	40	0.07	40	0.08	40
	30	0.03	45	0.05	45	0.06	50	0.08	45
	40	0.03	50	0.05	50	0.07	50	0.08	50
	50	0.03	55	0.05	55	0.06	50	0.08	50
10	2.0	0.09	25	0.10	5.0	0.09	0	0.08	0
	5.0	0.06	25	0.07	15	0.07	20	0.07	20
	10	0.05	30	0.06	30	0.06	30	0.07	35
	20	0.03	40	0.05	40	0.06	45	0.07	40
	30	0.03	40	0.05	45	0.06	47	0.07	45
	40	0.03	45	0.05	50	0.06	50	0.07	45
	50	0.03	50	0.04	50	0.06	50	0.07	50

MRF914

CASE 20-03, STYLE 10
TO-72 (TO-206AF)



HIGH FREQUENCY TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Peak	I_C	40	mAdc
Total Device Dissipation @ $T_A = 75°C$ Derate above 75°C	P_D	200 1.6	mW mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	625	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	12	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 20$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	30	—	200	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 20$ mAdc, $V_{CE} = 10$ Vdc, f = 0.5 GHz)	f_T	—	4.5	—	GHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	—	0.7	1.0	pF
FUNCTIONAL TEST					
Noise Figure ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 0.5 GHz) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 GHz)	NF	 — —	 2.0 2.5	 — —	dB
Power Gain at Optimum Noise Figure ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 0.5 GHz) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 GHz)	G_{NF}	 — —	 12 7.0	 — —	dB
Maximum Available Power Gain(1) ($I_C = 20$ mAdc, $V_{CE} = 10$ Vdc, f = 0.5 GHz) ($I_C = 20$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 GHz)	G_{max}	 — —	 15 10	 — —	dB

(1) $G_{max} = \frac{|S_{21}|^2}{(1 - |S_{11}|^2)(1 - |S_{22}|^2)}$

7

FIGURE 1 — POWER DERATING

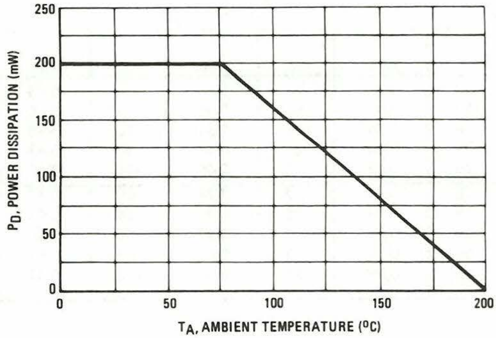


FIGURE 2 — POWER GAIN AND NOISE FIGURE versus FREQUENCY

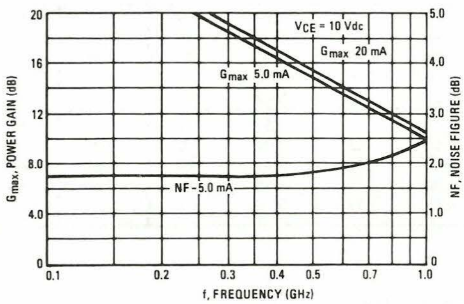


FIGURE 3 — POWER GAIN AND NOISE FIGURE versus COLLECTOR CURRENT

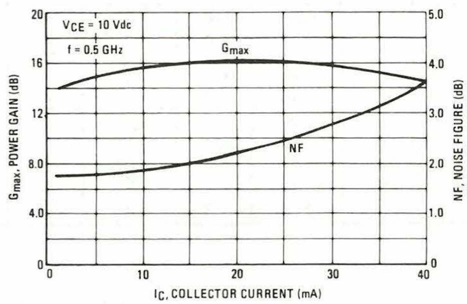


FIGURE 4 — S_{11} PARAMETERS

Frequency (MHz)		100		300		500		700		1000	
V_{CE} (Volts)	I_C (mA)	S11	∠φ	S11	∠φ	S11	∠φ	S11	∠φ	S11	∠φ
5.0	2.0	0.84	-35	0.57	-80	0.42	-115	0.34	-140	0.27	-166
	5.0	0.65	-45	0.34	-85	0.23	-115	0.18	-130	0.16	-150
	10	0.48	-50	0.32	-85	0.14	-105	0.12	-115	0.09	-120
	20	0.33	-50	0.15	-75	0.10	-90	0.09	-100	0.09	-101
	30	0.27	-50	0.13	-70	0.09	-85	0.09	-100	0.09	-101
10	2.0	0.86	-30	0.59	-75	0.42	-105	0.34	-130	0.25	-155
	5.0	0.70	-40	0.37	-75	0.24	-95	0.18	-110	0.13	-125
	10	0.55	-45	0.26	-70	0.17	-80	0.14	-90	0.13	-90
	20	0.41	-45	0.21	-60	0.15	-65	0.13	-75	0.14	-80
	30	0.36	-45	0.19	-55	0.14	-65	0.13	-75	0.13	-80

7

FIGURE 5 – S_{22} PARAMETERS

Frequency (MHz)		100		300		500		700		1000	
VCE (Volts)	IC (mA)	S22	∠φ	S22	∠φ	S22	∠φ	S22	∠φ	S22	∠φ
5.0	2.0	0.94	−15	0.77	−25	0.68	−30	0.66	−35	0.64	−45
	5.0	0.85	−20	0.63	−30	0.57	−30	0.55	−35	0.55	−45
	10	0.75	−25	0.55	−25	0.51	−30	0.50	−35	0.50	−40
	20	0.66	−25	0.50	−25	0.47	−30	0.47	−35	0.48	−40
	30	0.62	−25	0.49	−25	0.46	−25	0.46	−30	0.47	−40
10	2.0	0.95	−10	0.81	−20	0.74	−30	0.72	−35	0.71	−40
	5.0	0.87	−15	0.69	−25	0.64	−25	0.63	−30	0.63	−40
	10	0.80	−20	0.63	−20	0.59	−25	0.59	−30	0.60	−40
	20	0.72	−20	0.59	−20	0.57	−23	0.57	−30	0.58	−35
	30	0.70	−20	0.59	−20	0.57	−20	0.57	−30	0.58	−35

FIGURE 6 – S_{21} PARAMETERS

Frequency (MHz)		100		300		500		700		1000	
VCE (Volts)	IC mA	S21	∠φ	S21	∠φ	S21	∠φ	S21	∠φ	S21	∠φ
5.0	2.0	5.99	150	4.06	110	2.90	90	2.27	75	1.71	55
	5.0	11.38	135	5.91	100	3.90	80	2.93	70	2.17	55
	10	15.21	125	6.78	95	4.34	80	3.23	70	2.38	55
	20	17.98	115	7.27	90	4.58	75	3.40	65	2.50	50
	30	18.78	110	7.37	85	4.64	75	3.42	65	2.50	50
10	2.0	6.05	150	4.20	115	3.04	90	2.37	75	1.75	55
	5.0	11.46	135	6.17	100	4.06	85	3.08	70	2.26	55
	10	15.45	127	7.08	95	4.56	80	3.41	70	2.50	55
	20	18.35	120	7.57	90	4.80	75	3.58	65	2.61	55
	30	19.12	115	7.63	90	4.79	75	3.56	65	2.60	55

7

FIGURE 7 – S_{12} PARAMETERS

Frequency (MHz)		100		300		500		700		1000	
VCE (Volts)	IC (mA)	S12	∠φ	S12	∠φ	S12	∠φ	S12	∠φ	S12	∠φ
5.0	2.0	0.04	70	0.09	50	0.11	50	0.12	50	0.16	50
	5.0	0.04	70	0.07	60	0.11	60	0.14	60	0.19	55
	10	0.03	70	0.07	70	0.11	65	0.15	65	0.20	55
	20	0.03	75	0.07	70	0.12	70	0.15	65	0.21	55
	30	0.03	75	0.07	70	0.12	70	0.16	65	0.21	57
10	2.0	0.03	70	0.07	55	0.09	50	0.10	50	0.13	55
	5.0	0.03	70	0.06	60	0.09	65	0.12	60	0.15	60
	10	0.03	70	0.06	65	0.09	65	0.12	65	0.17	60
	20	0.03	75	0.06	70	0.09	70	0.13	65	0.18	60
	30	0.03	75	0.06	70	0.10	70	0.13	65	0.17	60

MRF931

CASE 317-01, STYLE 2

HIGH FREQUENCY TRANSISTOR

NPN SILICON

7

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	5.0	Vdc
Collector-Base Voltage	V_{CBO}	10	Vdc
Emitter-Base Voltage	V_{EBO}	2.0	Vdc
Collector Current — Peak	I_C	5.0	mAdc
Total Device Dissipation @ T_A = 100°C Derate above 100°C	P_D	50 1.0	mW mW/°C
Junction Temperature	T_J	+150	°C
Storage Temperature	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	500	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 0.1 mAdc, I_B = 0)	$V_{(BR)CEO}$	5.0	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.01 mAdc, I_E = 0)	$V_{(BR)CBO}$	10	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	2.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 5.0 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.25 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	30	—	150	—
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_E = 1.0 mAdc, V_{CE} = 1.0 Vdc, f = 1.0 GHz)	f_T	—	3.0	—	GHz
Collector-Base Capacitance (V_{CB} = 1.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	0.35	0.5	pF
FUNCTIONAL TEST					
Noise Figure (I_E = 0.25 mAdc, V_{CE} = 1.0 Vdc, f = 0.5 GHz) (I_E = 0.25 mAdc, V_{CE} = 1.0 Vdc, f = 1.0 GHz)	NF	 — —	 3.8 4.3	 — —	dB
Power Gain at Optimum Noise Figure (I_E = 0.25 mAdc, V_{CE} = 1.0 Vdc, f = 0.5 GHz) (I_E = 0.25 mAdc, V_{CE} = 1.0 Vdc, f = 1.0 GHz)	G_{NF}	 — —	 16 10	 — —	dB
Transducer Power Gain (I_E = 0.5 mAdc, V_{CE} = 1.0 Vdc, f = 0.5 GHz) (I_E = 0.5 mAdc, V_{CE} = 1.0 Vdc, f = 1.0 GHz)	G_T	 — —	 18 12	 — —	dB

FIGURE 1 — POWER DERATING

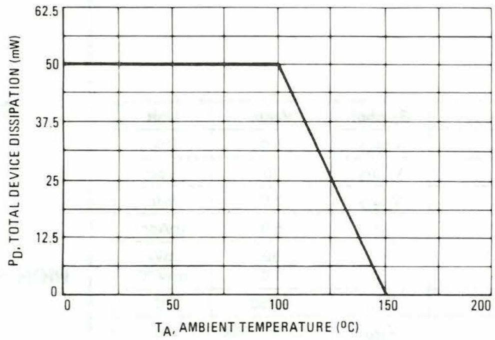


FIGURE 2 — TRANSDUCER POWER GAIN AND NOISE FIGURE versus FREQUENCY

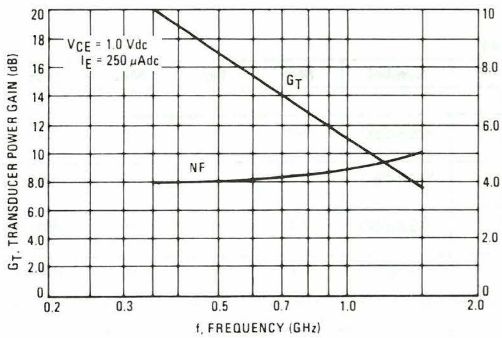
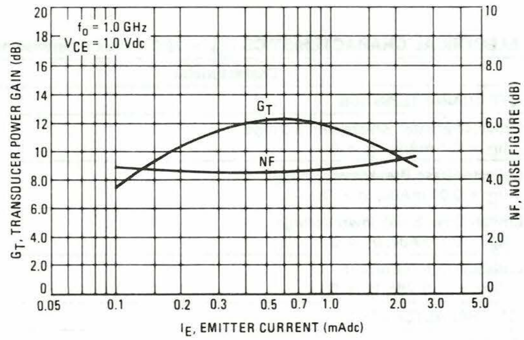


FIGURE 3 — TRANSDUCER POWER GAIN AND NOISE FIGURE versus EMITTER CURRENT



MRF966
MRF967

CASE 317-01, STYLE 1

DUAL GATE GaAs FET

N-CHANNEL

CASE 358-01, STYLE 2

DUAL GATE GaAs FET

N-CHANNEL

7

MAXIMUM RATINGS

Rating	Symbol	MRF966	MRF967	Unit
Drain-Source Voltage	V_{DS}	10	10	Vdc
Gate-Source Voltage — Reverse	V_{G1S}	−8.0 −8.0	−8.0 −8.0	Vdc
Gate-Source Voltage — Forward	V_{G1S} V_{G2S}	+1.0 +1.0	+1.0 +1.0	Vdc
Drain Current	I_D	60	60	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	 350 3.5	 350 3.5	 mW mW/°C
Junction Temperature Range	T_J	−65 to +125	−65 to +125	°C
Storage Channel Temperature Range	T_{stg}	−65 to +125	−65 to +125	°C

Handling and Packaging — MES devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MES devices should be observed.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage ($V_{G1S} = V_{G2S} = -4.0$ Vdc, $I_D = 100\ \mu A$)	$V_{(BR)DSX}$	10	—	—	Vdc
Gate 1 Leakage Current ($V_{G1S} = -5.0$ Vdc, $V_{G2S} = V_{DS} = 0$)	I_{G1SS}	—	—	10	μAdc
Gate 2 Leakage Current ($V_{G2S} = -5.0$ Vdc, $V_{G1S} = V_{DS} = 0$)	I_{G2SS}	—	—	10	μAdc
Gate 1 to Source Cutoff Voltage ($V_{DS} = 5.0$ Vdc, $V_{G2S} = 0$)	$V_{G1S(off)}$	−2.0	—	−4.5	Vdc
Gate 2 to Source Cutoff Voltage ($V_{DS} = 5.0$ Vdc, $V_{G1S} = 0$)	$V_{G2S(off)}$	−2.0	—	−4.5	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain ($V_{DS} = 5.0$ Vdc, $V_{G1S} = V_{G2S} = 0$)	I_{DSS}	30	50	80	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance ($V_{DS} = 5.0$ Vdc, $V_{G2S} = 0$, $I_D = 10$ mA, f = 1.0 kHz)	$\|y_{fs}\|$	14	20	—	mmhos
Input Capacitance ($V_{DS} = 5.0$ Vdc, $V_{G2S} = 0$, $I_D = 10$ mA, f = 1.0 MHz)	C_{iss}	—	0.45	—	pF
Reverse Transfer Capacitance ($V_{DS} = 5.0$ Vdc, $V_{G2S} = 0$, $I_D = 10$ mA, f = 1.0 MHz)	C_{rss}	—	0.04	—	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure ($V_{DS} = 5.0$ Vdc, $V_{G2S} = 0(1)$, $I_{DS} = 10$ mA, f = 1.0 GHz)	NF	—	1.2	1.5	dB
Common Source Power Gain ($V_{DS} = 5.0$ Vdc, $V_{G2S} = 0(1)$, MRF967 $I_{DS} = 10$ mA, f = 1.0 GHz) MRF966	G_{ps}	 13 15	 15 18	 — —	dB
Intermodulation Distortion ($V_{DS} = 5.0$ Vdc, $I_{DS} = 10$ mA, $f_1 = 995$ MHz, $f_2 = 1001$ MHz, $V_{G2} = 0$, $P_{in} = -40$ dBm)	IMD_3	—	−65	—	dB

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Linear Power Point(2) (V_{DS} = 5.0 Vdc, I_{DS} = 10 mA, f_1 = 995 MHz, f_2 = 1001 MHz, V_{G2} = 0)	P_L	—	+1.0	—	dBm
Output Power at 1 dB Compression Point (V_{DS} = 5.0 Vdc, I_{DS} = 10 mA, f = 1.0 GHz)	P_{out}	—	10	—	dBm

(1) Data taken using a HP11608A 50 Ω test fixture, Microlab slug tuners, HP11590A bias networks and the HP8970A noise figure meter. Note: V_{G2S} = 0. Refer to Figure 16.

(2) The linear power point is the output power level at which either the signal $2f_1 \pm f_2$ or $2f_2 \pm f_1$ are 30 dB below f_1 or f_2.

TYPICAL CHARACTERISTICS
MRF966

FIGURE 1 — DRAIN CURRENT versus DRAIN-TO-SOURCE VOLTAGE

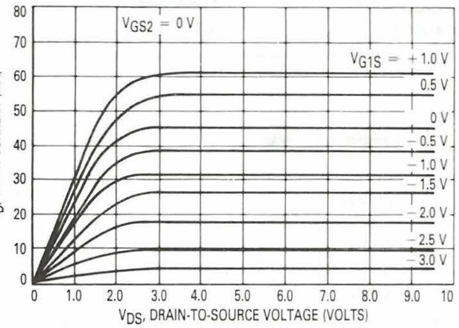


FIGURE 2 — DRAIN CURRENT versus GATE ONE-TO-SOURCE VOLTAGE

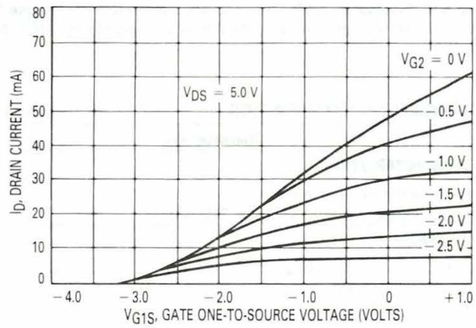


FIGURE 3 — COMMON SOURCE POWER GAIN AND NOISE FIGURE versus DRAIN-TO-SOURCE VOLTAGE

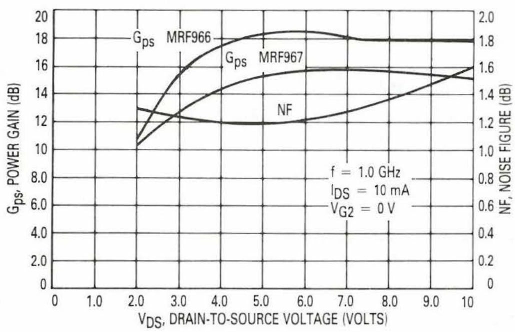


FIGURE 4 — COMMON-SOURCE POWER GAIN AND NOISE FIGURE versus PERCENT-OF-DRAIN CURRENT

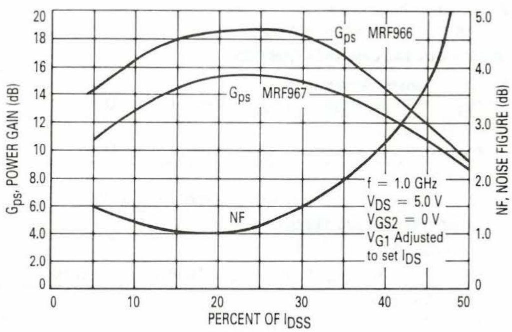


FIGURE 5 — COMMON SOURCE POWER GAIN AND NOISE FIGURE versus GATE ONE-TO-SOURCE VOLTAGE

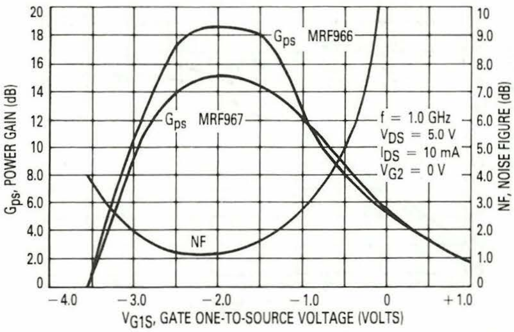


FIGURE 6 — COMMON SOURCE POWER GAIN AND NOISE FIGURE versus GATE CONTROL SUPPLY VOLTAGE

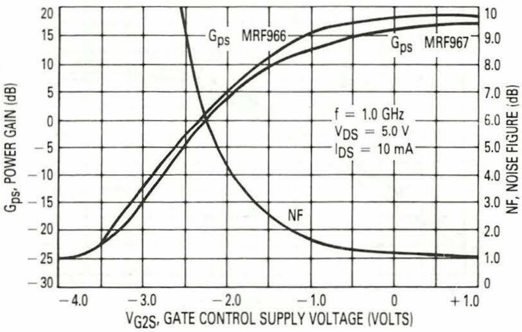


FIGURE 7 — COMMON SOURCE POWER GAIN AND NOISE FIGURE versus FREQUENCY

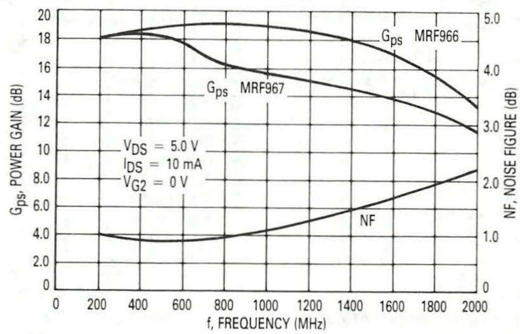


FIGURE 8 — MAXIMUM AVAILABLE GAIN AND STABILITY FACTOR versus FREQUENCY

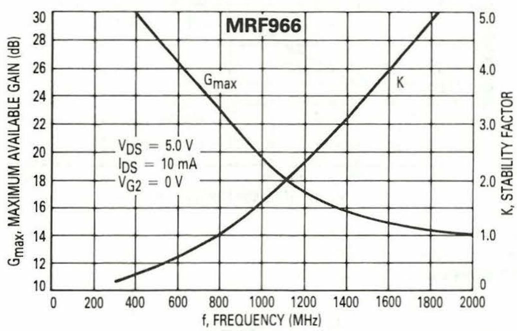


FIGURE 9 — MAXIMUM AVAILABLE GAIN AND STABILITY FACTOR versus FREQUENCY

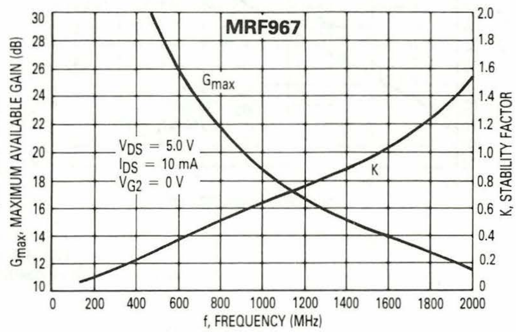


FIGURE 10 — OUTPUT POWER versus INPUT POWER @ 500 MHz

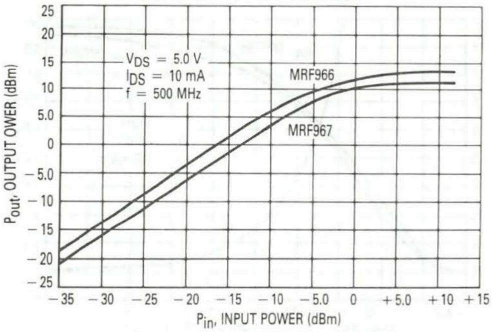
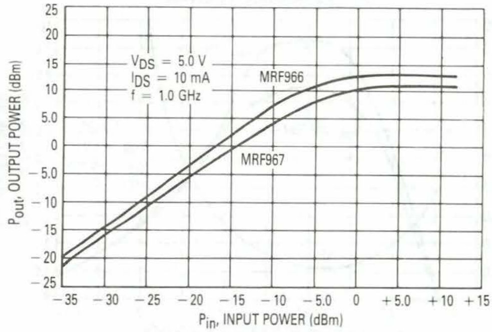


FIGURE 11 — OUTPUT POWER versus INPUT POWER @ 1.0 GHz



TYPICAL CHARACTERISTICS
MRF967

FIGURE 12 — THIRD ORDER INTERMODULATION DISTORTION @ 500 MHz

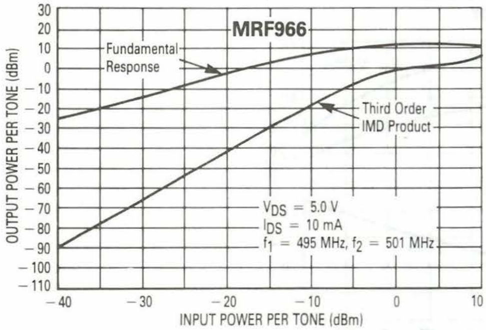


FIGURE 13 — THIRD ORDER INTERMODULATION DISTORTION @ 500 MHz

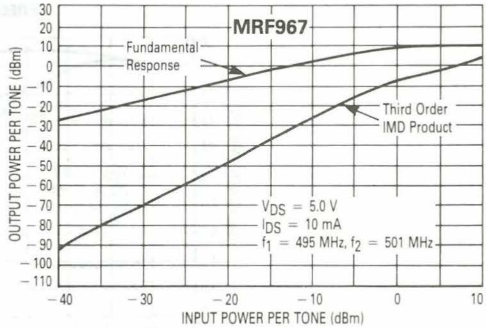


FIGURE 14 — THIRD ORDER INTERMODULATION DISTORTION @ 1.0 GHz

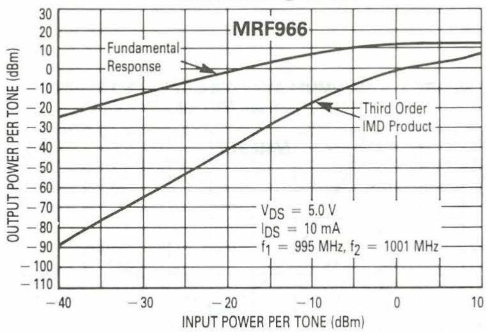


FIGURE 15 — THIRD ORDER INTERMODULATION DISTORTION @ 1.0 GHz

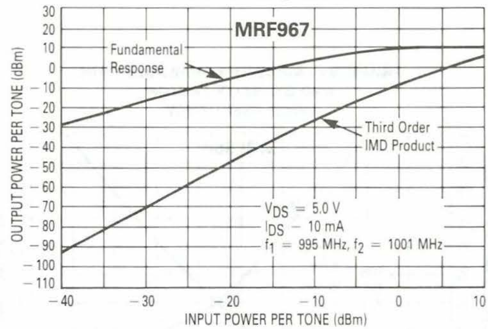
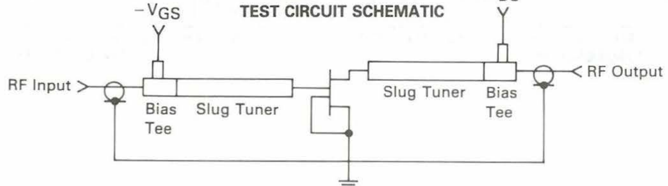
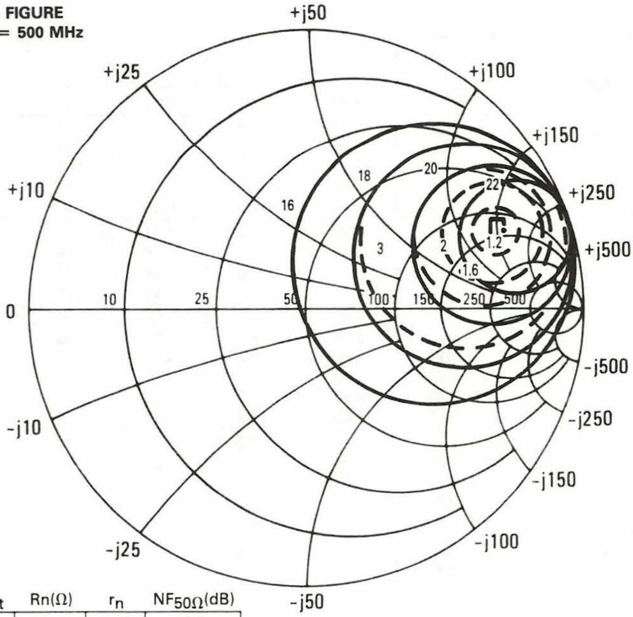


FIGURE 16 — 1.0 GHz TEST CIRCUIT SCHEMATIC



MRF966

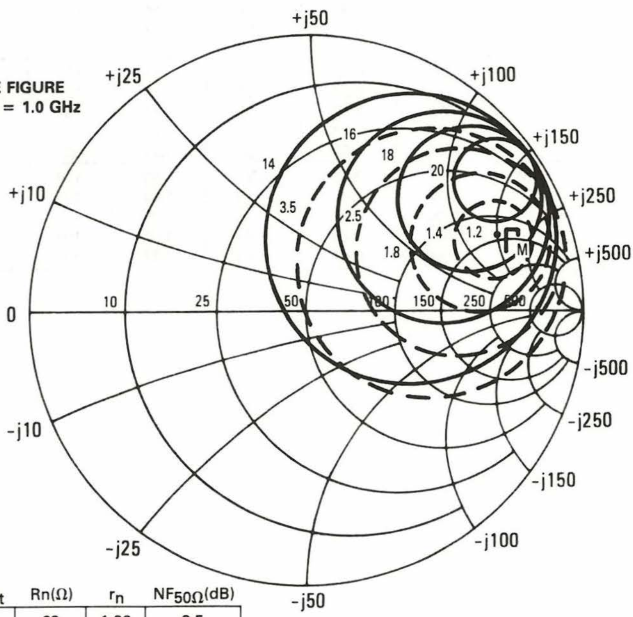
FIGURE 17 — CONSTANT GAIN AND NOISE FIGURE CONTOURS AT V_{DS} = 5.0 V, I_{DS} = 10 mA, f = 500 MHz (MATCHED OUTPUT)



f(MHz)	NF_{opt}(dB)	ΓMS NF_{opt}	ΓML NF_{opt}	Rn(Ω)	r_n	$NF_{50\Omega}$(dB)
500	1.0	0.76/22°	0.75/14°	101.5	2.03	4.5

7

FIGURE 18 — CONSTANT GAIN AND NOISE FIGURE CONTOURS AT V_{DS} = 5.0 V, I_{DS} = 10 mA, f = 1.0 GHz (MATCHED OUTPUT)



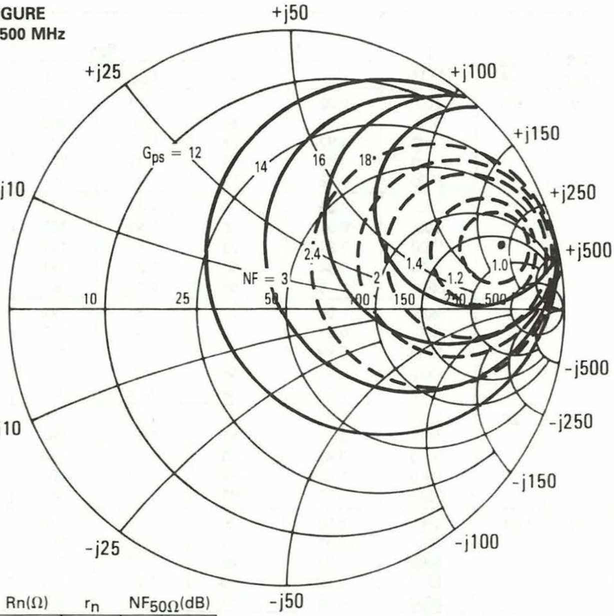
f(MHz)	NF_{opt}(dB)	ΓMS NF_{opt}	ΓML NF_{opt}	Rn(Ω)	r_n	$NF_{50\Omega}$(dB)
1000	1.2	0.74/21°	0.77/12°	63	1.26	3.5

MRF966 COMMON-SOURCE S-PARAMETERS

V_{DS} (Volts)	I_{DS} (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	$\angle\phi$	$\|S_{21}\|$	$\angle\phi$	$\|S_{12}\|$	$\angle\phi$	$\|S_{22}\|$	$\angle\phi$
3.0	5.0	200	0.99	−4.0	1.10	171	0.002	94	0.96	−3.0
		500	0.96	−12	1.07	155	0.004	79	0.95	−8.0
		1000	0.92	−24	1.06	134	0.008	71	0.93	−17
		1500	0.84	−38	1.00	112	0.008	70	0.90	−26
		2000	0.71	−49	0.96	90	0.006	100	0.86	−34
	10	200	0.99	−5.0	1.31	171	0.002	82	0.95	−3.0
		500	0.96	−13	1.28	155	0.005	78	0.94	−8.0
		1000	0.90	−26	1.25	134	0.008	73	0.91	−17
		1500	0.81	−40	1.19	112	0.009	72	0.88	−27
		2000	0.67	−51	1.08	90	0.008	100	0.84	−35
	15	200	0.99	−5.0	1.34	170	0.002	92	0.93	−3.0
		500	0.96	−14	1.30	155	0.005	78	0.93	−8.0
		1000	0.90	−27	1.29	133	0.009	73	0.91	−17
		1500	0.79	−42	1.23	111	0.009	74	0.87	−26
		2000	0.65	−53	1.12	88	0.009	98	0.83	−34
	20	200	0.99	−5.0	1.24	170	0.002	95	0.91	−3.0
		500	0.96	−15	1.21	154	0.006	80	0.90	−8.0
		1000	0.89	−29	1.20	131	0.010	74	0.88	−17
		1500	0.79	−45	1.17	108	0.011	74	0.85	−26
		2000	0.64	−57	1.08	84	0.012	94	0.83	−33
5.0	5.0	200	0.99	−5.0	1.33	170	0.001	84	0.97	−3.0
		500	0.98	−13	1.29	156	0.004	70	0.97	−9.0
		1000	0.90	−27	1.25	132	0.006	78	0.95	−17
		1500	0.81	−40	1.19	112	0.005	73	0.91	−25
		2000	0.68	−51	1.00	94	0.006	115	0.88	−35
	10	200	0.99	−5.0	1.66	170	0.001	75	0.97	−3.0
		500	0.97	−14	1.63	156	0.004	76	0.96	−9.0
		1000	0.89	−28	1.56	132	0.006	79	0.94	−17
		1500	0.78	−41	1.47	112	0.005	80	0.90	−25
		2000	0.65	−52	1.23	94	0.007	121	0.87	−35
	15	200	0.99	−5.0	1.84	170	0.001	78	0.96	−3.0
		500	0.97	−14	1.80	155	0.004	72	0.95	−8.0
		100	0.89	−29	1.71	131	0.006	79	0.94	−17
		1500	0.77	−42	1.61	110	0.005	83	0.90	−25
		2000	0.63	−52	1.34	93	0.007	119	0.87	−34
	20	200	0.99	−5.0	1.89	170	0.001	71	0.96	−3.0
		500	0.97	−15	1.84	155	0.004	78	0.95	−9.0
		1000	0.87	−30	1.75	130	0.006	80	0.93	−17
		1500	0.75	−43	1.64	109	0.006	84	0.90	−24
		2000	0.61	−54	1.37	91	0.008	123	0.87	−34

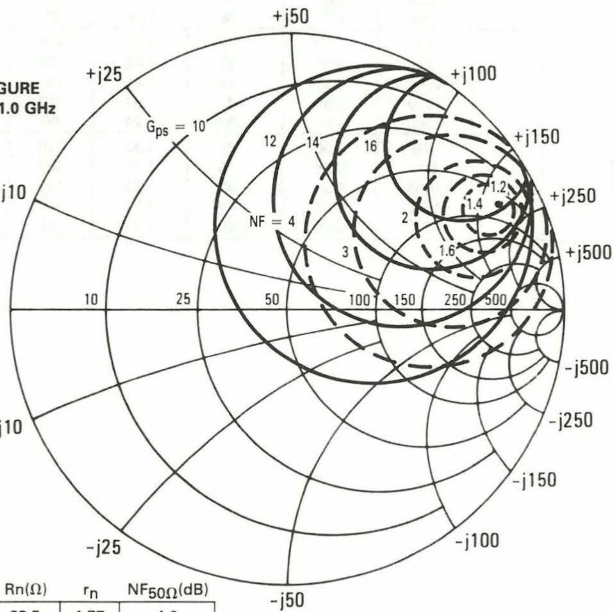
MRF967

FIGURE 19 — CONSTANT GAIN AND NOISE FIGURE CONTOURS AT V_{DS} = 5.0 V, I_{DS} = 10 mA, f = 500 MHz (MATCHED OUTPUT)



f(MHz)	NF_{opt}(dB)	ΓMS NF_{opt}	ΓML NF_{opt}	Rn(Ω)	r_n	$NF_{50\Omega}$(dB)
500	1.0	0.81/16°	0.76/21°	63	1.26	3.6

FIGURE 20 — CONSTANT GAIN AND NOISE FIGURE CONTOURS AT V_{DS} = 5.0 V, I_{DS} = 10 mA, f = 1.0 GHz (MATCHED OUTPUT)



f(MHz)	NF_{opt}(dB)	ΓMS NF_{opt}	ΓML NF_{opt}	Rn(Ω)	r_n	$NF_{50\Omega}$(dB)
1000	1.2	0.84/26°	0.82/17°	88.5	1.77	4.6

7

MRF967 COMMON-SOURCE S-PARAMETERS

V_{DS} (Volts)	I_{DS} (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	$\angle\phi$	$\|S_{21}\|$	$\angle\phi$	$\|S_{12}\|$	$\angle\phi$	$\|S_{22}\|$	$\angle\phi$
3.0	5.0	200	0.99	−5	1.19	170	0.005	77	0.96	−4
		500	0.97	−14	1.16	155	0.016	73	0.94	−11
		1000	0.92	−27	1.11	131	0.030	65	0.93	−21
		1500	0.86	−40	1.03	111	0.040	54	0.87	−31
		2000	0.78	−52	0.96	91	0.048	45	0.83	−43
	10	200	0.99	−5	1.47	170	0.006	81	0.95	−4
		500	0.97	−15	1.43	155	0.016	73	0.93	−11
		1000	0.91	−29	1.39	131	0.031	65	0.92	−21
		1500	0.84	−43	1.29	111	0.040	54	0.86	−31
		2000	0.75	−56	1.19	90	0.047	45	0.81	−44
	15	200	1.00	−6	1.50	170	0.006	82	0.93	−4
		500	0.97	−16	1.46	155	0.016	74	0.91	−11
		1000	0.89	−31	1.42	131	0.031	64	0.90	−21
		1500	0.83	−46	1.33	110	0.040	53	0.84	−31
		2000	0.73	−59	1.24	89	0.048	45	0.79	−43
	20	200	1.00	−6	1.33	170	0.007	78	0.90	−3
		500	0.97	−17	1.30	154	0.017	73	0.88	−10
		1000	0.89	−33	1.27	129	0.033	64	0.88	−21
		1500	0.82	−49	1.21	108	0.043	53	0.82	−30
		2000	0.73	−63	1.14	86	0.050	44	0.78	−42
5.0	5.0	200	0.99	−5	1.17	170	0.006	84	0.97	−3
		500	0.97	−14	1.16	155	0.014	76	0.97	−9
		1000	0.93	−27	1.11	131	0.027	65	0.94	−18
		1500	0.87	−28	1.07	110	0.039	57	0.93	−28
		2000	0.79	−53	0.97	91	0.045	50	0.88	−37
	10	200	0.99	−5	1.47	170	0.006	84	0.97	−3
		500	0.97	−15	1.43	156	0.014	76	0.96	−9
		1000	0.92	−29	1.35	132	0.027	65	0.93	−18
		1500	0.85	−44	1.32	111	0.038	57	0.90	−29
		2000	0.77	−56	1.19	91	0.044	49	0.86	−37
	15	200	1.00	−6	1.53	170	0.006	85	0.96	−3
		500	0.98	−15	1.48	156	0.014	77	0.95	−9
		1000	0.91	−29	1.41	131	0.027	64	0.93	−18
		1500	0.85	−46	1.37	110	0.038	57	0.90	−28
		2000	0.75	−58	1.24	90	0.043	49	0.86	−36
	20	200	1.00	−6	1.32	170	0.006	85	0.95	−3
		500	0.98	−16	1.29	155	0.015	76	0.95	−8
		1000	0.91	−32	1.23	129	0.027	64	0.92	−17
		1500	0.88	−49	1.21	107	0.038	55	0.90	−27
		2000	0.75	−62	1.11	87	0.043	48	0.86	−36

MRF8003

CASE 79-02, STYLE 1
TO-39 (TO-205AD)

RF AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

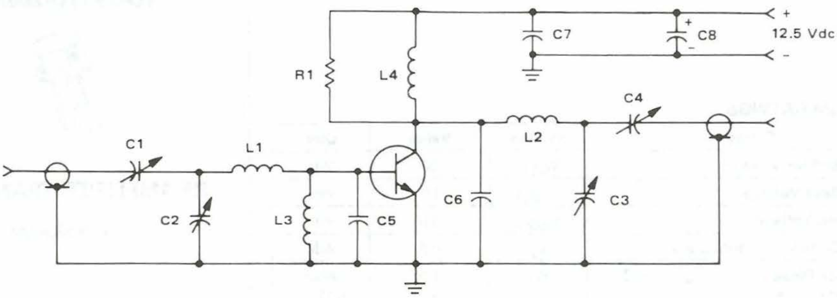
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	0.5	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.7	Watt mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 0.1$ mAdc, $V_{BE} = 0$)	$V_{(BR)CES}$	50	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.5$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 12$ Vdc, $I_E = 0$)	I_{CBO}	—	—	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 100$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	20	—	—	—
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance ($V_{CB} = 12.5$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{obo}	—	—	15	pF
FUNCTIONAL TEST (FIGURE 1)					
Common-Emitter Amplifier Power Gain ($V_{CC} = 12.5$ Vdc, $P_{out} = 0.5$ W, f = 27 MHz)	G_{PE}	10	—	—	dB
Collector Efficiency ($V_{CC} = 12.5$ Vdc, $P_{out} = 0.5$ W, f = 27 MHz)	η		50		%

7

FIGURE 1 — 27 MHz TEST CIRCUIT SCHEMATIC

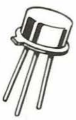


C1, C2, C3, C4	9.0-180 pF ARCO 463 or equivalent
C5	25 pF UNDERWOOD
C6	100 pF UNDERWOOD
C7	1000 pF UNDERWOOD
C8	10 μF ELECTROLYTIC
L1, L2	0.47 μH Molded Coil
L3	VK 200-20/4B RFC
L4	16 Turns No. 26 Wire Closewound on R1
R1	390 Ω, 2 W

7

MRF8004

CASE 79-02, STYLE 1
TO-39 (TO-205AD)



RF AMPLIFIER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_C = 25°C(1) Derate above 25°C	P_D	 5.0 28.6	 Watts mW/°C
Storage Temperature	T_{stg}	−65 to +200	°C

(1) This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

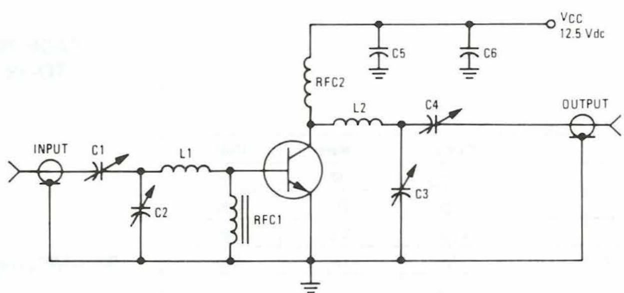
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 200 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	0.01	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 400 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	10	—	—	—
SMALL SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	35	70	pF
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (See Figure 1) (P_{out} = 3.5 W, V_{CC} = 12.5 Vdc, f = 27 MHz)	G_{PE}	10	—	—	dB
Collector Efficiency(2) (See Figure 1) (P_{out} = 3.5 W, V_{CC} = 12.5 Vdc, f = 27 MHz)	η	62.5	70	—	%
Percentage Up-Modulation(1) (See Figure 1) (f = 27 MHz)	—	—	85	—	%
Parallel Equivalent Input Resistance (P_{out} = 3.5 W, V_{CC} = 12.5 Vdc, f = 27 MHz)	R_{in}	—	21	—	Ohms
Parallel Equivalent Input Capacitance (P_{out} = 3.5 W, V_{CC} = 12.5 Vdc, f = 27 MHz)	C_{in}	—	900	—	pF
Parallel Equivalent Output Capacitance (P_{out} = 3.5 W, V_{CC} = 12.5 Vdc, f = 27 MHz)	C_{out}	—	200	—	pF

(1) Percentage Up-Modulation is measured in the test circuit (Figure 1) by setting the Carrier Power (P_c) to 3.5 Watts with V_{CC} = 12.5 Vdc and noting the power input. Then the Peak Envelope Power (PEP) is noted after doubling the original power input to simulate driver modulation (at a 25% duty cycle for thermal considerations) and raising the V_{CC} to 25 Vdc (to simulate the modulating voltage). Percentage Up-Modulation is then determined by the relation:

$$\text{Percentage Up-Modulation} = \left[\left(\frac{PEP}{P_c}\right)^{1/2} - 1\right] \cdot 100$$

(2) $\eta = \dfrac{R_F\, P_{out}}{(V_{CC})\,(I_C)} \cdot 100$

FIGURE 1 – 27 MHz TEST CIRCUIT



C1, C2	9.0-180 pF ARCO 463 or Equivalent
C3, C4	5.0-80 pF ARCO 462 or Equivalent
C5	0.02 μF Ceramic Disc
C6	0.1 μF Ceramic Disc
RFC1	4 Turns #30 Enameled Wire Wound on Ferroxcube Bead Type 56-590-65/3B
RFC2	26 Turns #22 Enameled Wire (2 Layers – 13 Turns Each Layer) ¼" Inner Diameter
L1	0.22 μH Molded Choke
L2	0.68 μH Molded Choke

(1) This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.

7

FIGURE 2 – CIRCUIT TUNED AT 25 V, 25% DUTY CYCLE, P_{out} = 15 W PEAK

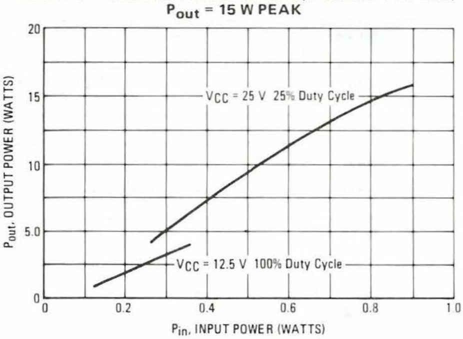
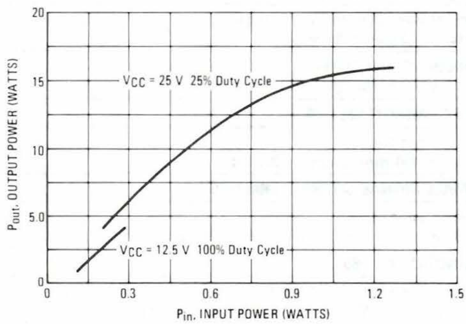


FIGURE 3 – CIRCUIT TUNED AT 12.5 V, P_{out} = 4 W



MWA110
MWA120
MWA130

CASE 31A-01, STYLE 2

GENERAL PURPOSE HYBRID AMPLIFIERS

MAXIMUM RATINGS

Rating	Symbol	Value MWA110	MWA120	MWA130	Unit
RF Input Power	P_{in}	100			mW
DC Supply Current	I_D	25	55	100	mA
Maximum Case Temperature	T_C	125			°C
Storage Temperature Range	T_{stg}	−65 to +200			°C

OPERATING CONDITIONS

Device Voltage	V_D	2.9	5.0	5.5	Vdc
Device Current	I_D	10	25	60	mAdc
Decoupling Impedance	Z_D	1000	1000	330	Ω

ELECTRICAL CHARACTERISTICS (T_C = −25 to +125°C, 50 Ω system and specified operating conditions.)

Characteristic		Symbol	Min	Typ	Max	Unit
Frequency Range		BW	0.1	—	400	MHz
Power Gain		G_p	13	14	—	dB
Response Flatness		F	—	0	±1.0	dB
Input VSWR						
	MWA110/120	—	—	—	2.5:1	—
	MWA130	—	—	—	3:1	—
Output VSWR	MWA110/120/130	—	—	—	2.5:1	—
Output @ 1.0 dB Gain Compression						dBm
	MWA110		—	−2.5	—	
	MWA120		—	+8.2	—	
	MWA130		—	+18	—	
Noise Figure		NF				dB
	MWA110		—	4.0	—	
	MWA120		—	5.5	—	
	MWA130		—	7.0	—	
Reverse Isolation		P_{RI}				dB
	MWA110		—	18.8	—	
	MWA120		—	19.2	—	
	MWA130		—	16.8	—	
Harmonic Output		d_{so}				dB
	MWA110 (P_{out} = −9.0 dBm)		—	−24	—	
	MWA120 (P_{out} = 0 dBm)		—	−34	—	
	MWA130 (P_{out} = +10 dBm)		—	−35	—	

7

FIGURE 1 — DEVICE VOLTAGE versus DEVICE CURRENT

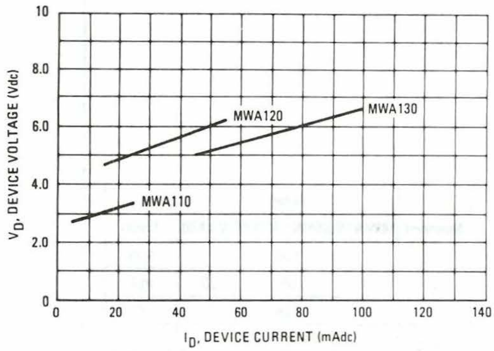


FIGURE 2 — DEVICE CURRENT versus CASE TEMPERATURE

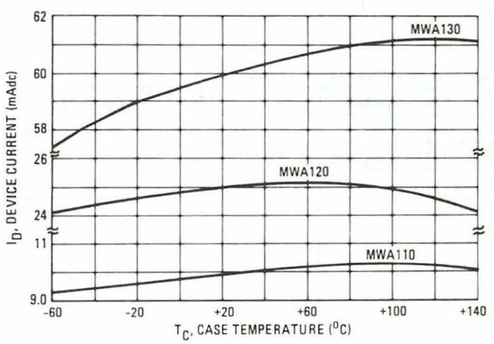
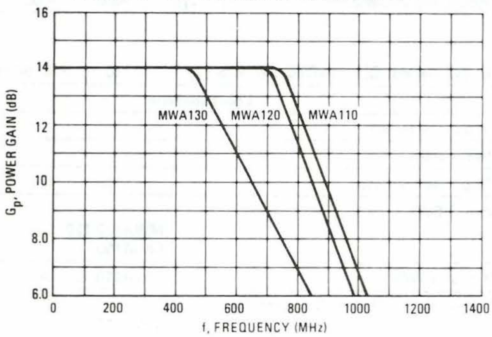


FIGURE 3 — POWER GAIN versus FREQUENCY



7

FIGURE 4 — POWER GAIN versus DEVICE CURRENT
f = 400 MHz

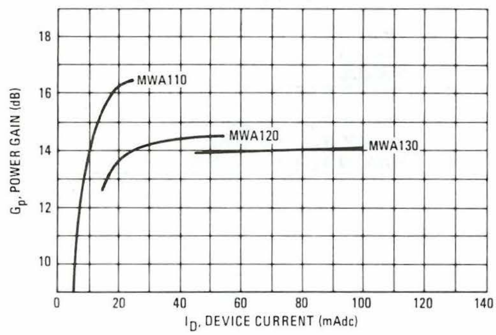


FIGURE 5 – POWER GAIN versus CASE TEMPERATURE
f = 100 MHz

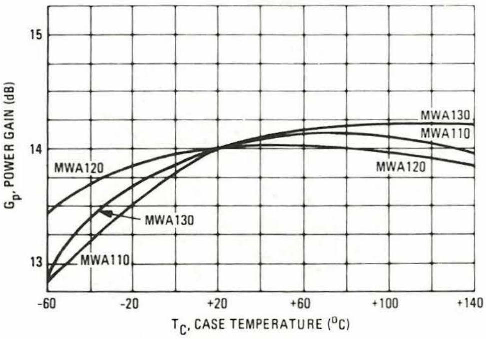


FIGURE 6 – POWER GAIN versus CASE TEMPERATURE
f = 400 MHz

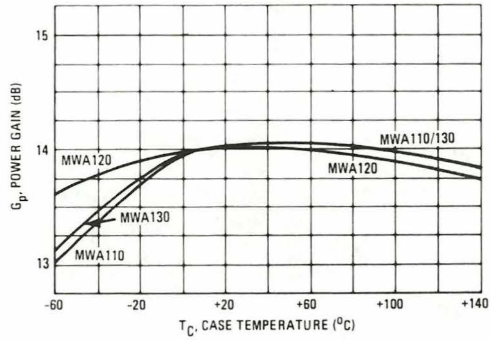


FIGURE 7 – VSWR versus FREQUENCY
MWA110

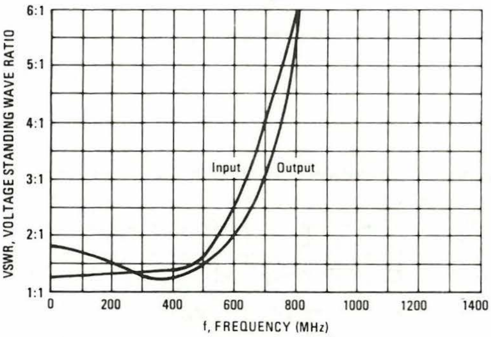


FIGURE 8 – VSWR versus FREQUENCY
MWA120

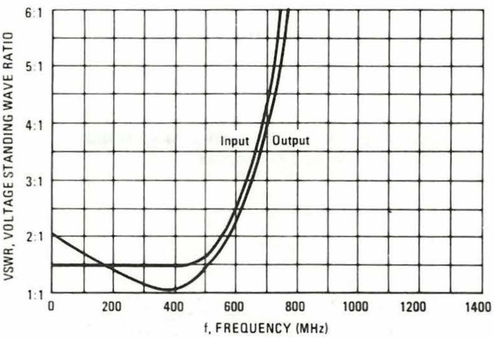
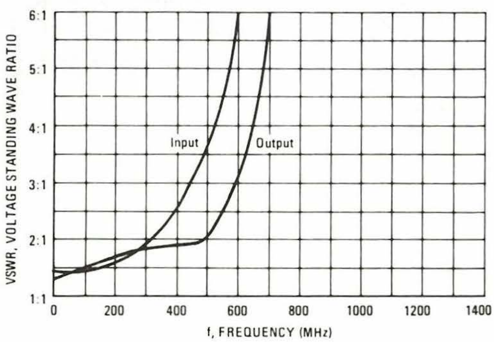


FIGURE 9 – VSWR versus FREQUENCY
MWA130



7

FIGURE 10 — INPUT AND OUTPUT IMPEDANCE versus FREQUENCY MWA110

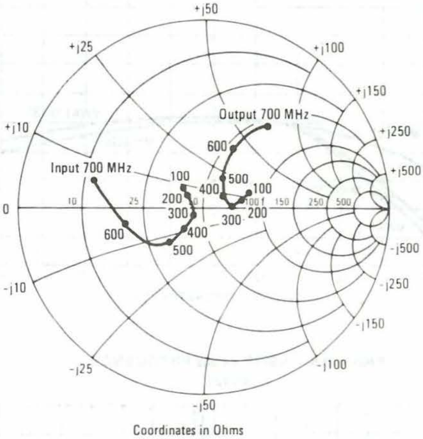


FIGURE 11 — INPUT AND OUTPUT IMPEDANCE versus FREQUENCY MWA120

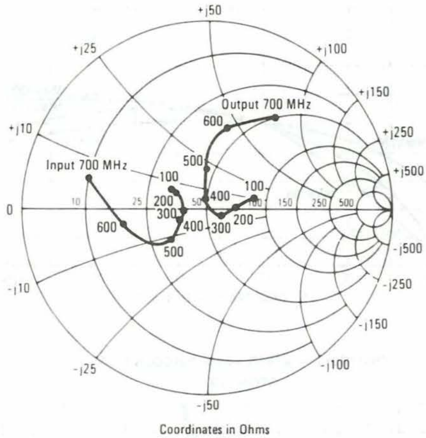


FIGURE 12 — INPUT AND OUTPUT IMPEDANCE versus FREQUENCY MWA130

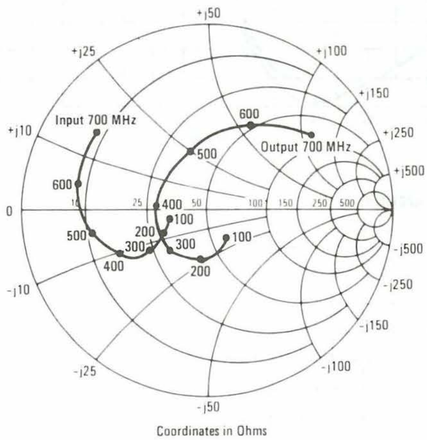
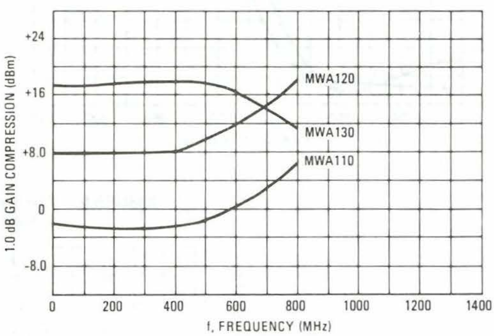


FIGURE 13 — 1.0 dB GAIN COMPRESSION versus FREQUENCY



7

FIGURE 14 – 1.0 dB GAIN COMPRESSION
versus DEVICE CURRENT
f = 400 MHz

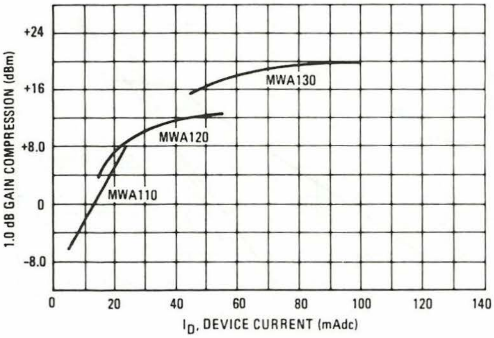


FIGURE 15 – 1.0 dB GAIN COMPRESSION
versus CASE TEMPERATURE
f = 400 MHz

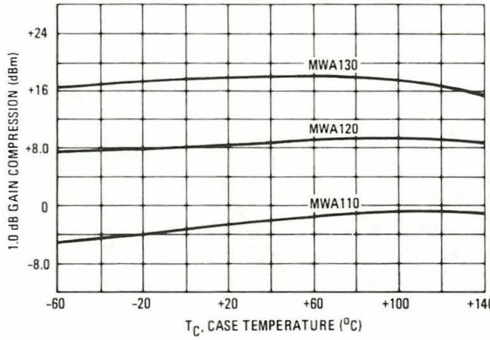


FIGURE 16 – NOISE FIGURE versus FREQUENCY

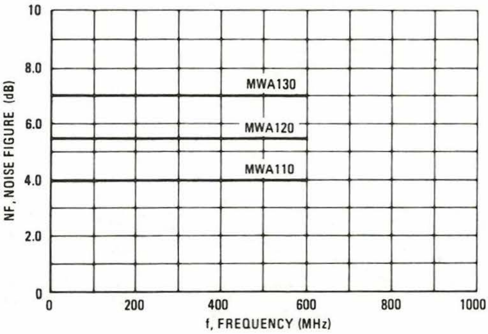


FIGURE 17 – REVERSE ISOLATION versus FREQUENCY

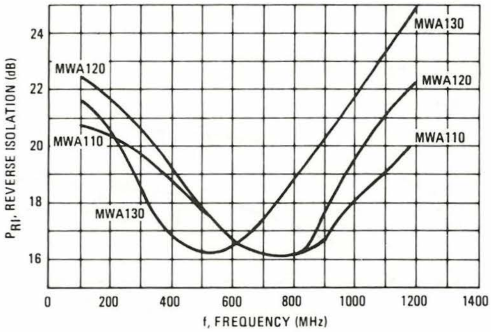


FIGURE 18 – SECOND HARMONIC OUTPUT versus FREQUENCY

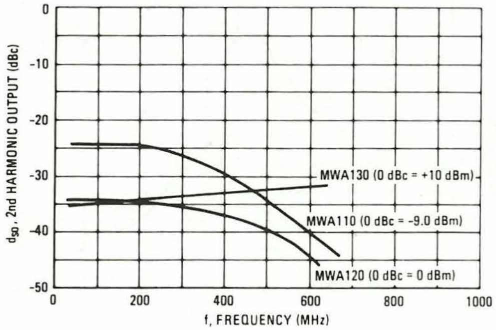


FIGURE 19 – SECOND AND THIRD ORDER INTERCEPT
MWA110

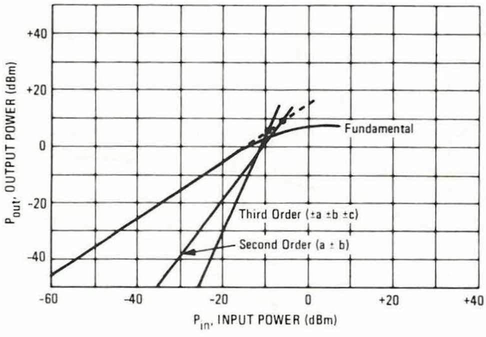


FIGURE 20 – SECOND AND THIRD ORDER INTERCEPT
MWA120

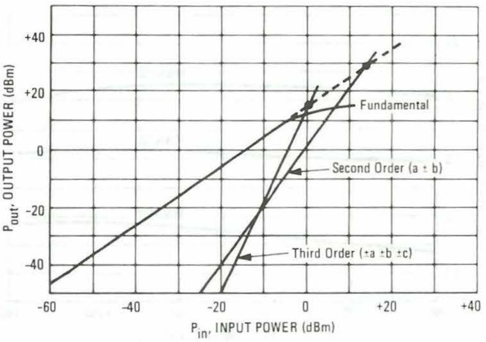


FIGURE 21 – SECOND AND THIRD ORDER INTERCEPT
MWA130

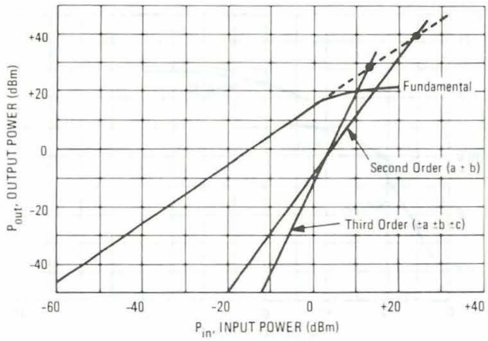


FIGURE 22 – INTERMODULATION DISTORTION
versus POWER OUTPUT
MWA110

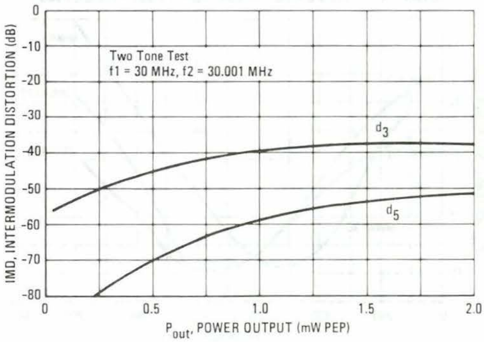


FIGURE 23 – INTERMODULATION DISTORTION
versus POWER OUTPUT
MWA120

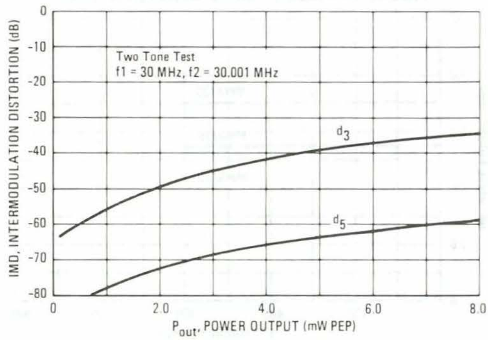


FIGURE 24 – INTERMODULATION DISTORTION
versus POWER OUTPUT
MWA130

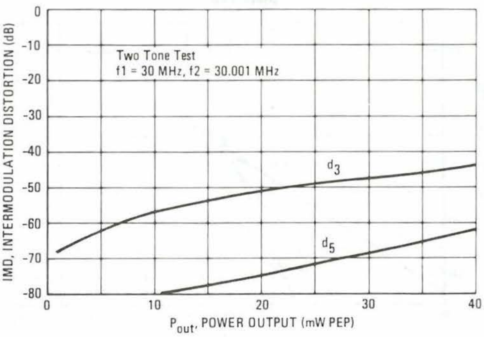
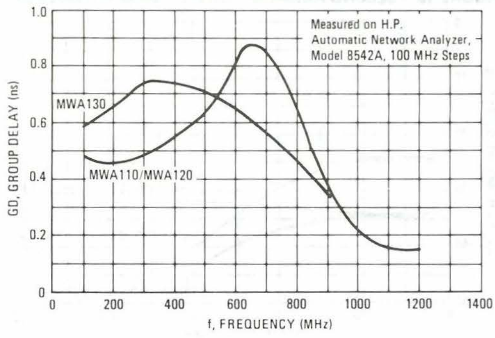


FIGURE 25 – GROUP DELAY versus FREQUENCY



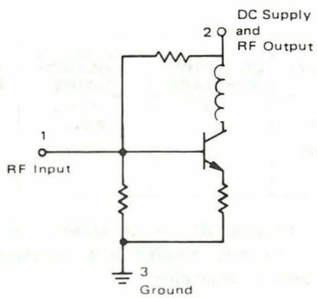
MWA SERIES HYBRID AMPLIFIER APPLICATIONS INFORMATION

The MWA series hybrid amplifiers are designed for wideband general purpose applications in 50 Ω systems. Fully cascadable for any gain combination, operable at voltages as low as 3 Vdc, and external control of the low frequency corner make the MWA amplifiers extremely versatile gain blocks.

Basic Circuit Configuration

Figure 26 shows the basic internal circuit. It is important to note that the specified operating conditions of voltage, current, and external decoupling impedance must be applied to the units in order to achieve the published electrical characteristics.

FIGURE 26 — INTERNAL CIRCUIT



Amplifier Application

The circuit schematic for a simple amplifier design is shown in Figure 27. External to the MWA hybrid amplifier the only components required are:

Decoupling elements — Bypass Capacitor
Decoupling Impedance
(resistor/inductor)

DC Blocking Capacitors at the RF input and output.

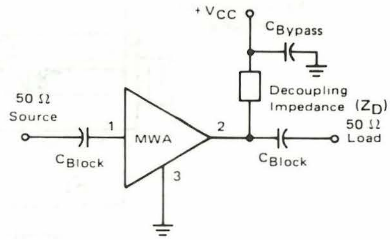
External Decoupling Impedance

In all cases the external bias (decoupling elements) must present an impedance which is large compared to the 50 Ω load impedance to minimize RF gain reduction. The loss in gain due to the decoupling impedance is given by the equation:

$$\text{Loss} = 20 \text{ Log } \frac{Z_D}{Z_D + 25} \text{ dB}$$

where Z_D = decoupling impedance in ohms. For example, if Z_D = 1 kΩ, Loss = 0.214 dB.

FIGURE 27 — AMPLIFIER SCHEMATIC DIAGRAM



Supply Voltage

The value of the external decoupling resistive impedance (R_D) determines the supply voltage ($+V_{CC}$) and is determined by the following equation:

$$V_{CC} = R_D \times I_D + V_D$$

where I_D and V_D are the device current and voltage stated in the data sheet. For example, for MWA110,

$$I_D = 10 \text{ mA}$$
$$V_D = 2.9 \text{ V}$$

and, if R_D = 330 Ω, then

$$V_{CC} = 6.2 \text{ V}$$

More commonly V_{CC} is predetermined and R_D may be calculated from:

$$R_D = \frac{V_{CC} - V_D}{I_D}$$

If an RF choke is used for decoupling, then the supply voltage (V_{CC}) required is equal to the device voltage (V_D).

Low Frequency Response

The value of the blocking capacitors determines the low frequency response of the amplifier. The following expression is used to determine the blocking capacitor value to yield a desired 3 dB low frequency corner (f_{LFC}).

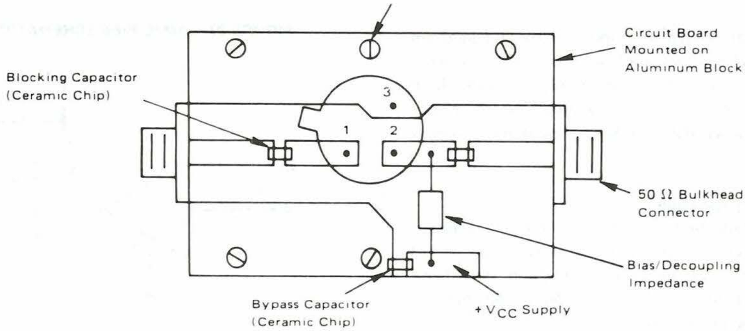
$$C_{Block}(\text{Farads}) = \frac{1}{100\,\pi\, f_{LFC}(\text{Hz})}$$

Bypass Capacitor

The reactive impedance of the bypass capacitor should be small compared to the impedance of the decoupling element at the lowest frequency of operation.

7

FIGURE 28 — TEST FIXTURE



Note: The circuitry indicated is on the underside of the printed circuit board with sockets for the amplifier pins. The case of the amplifier should contact the printed circuit board top surface to ensure effective RF grounding.

Text Fixture

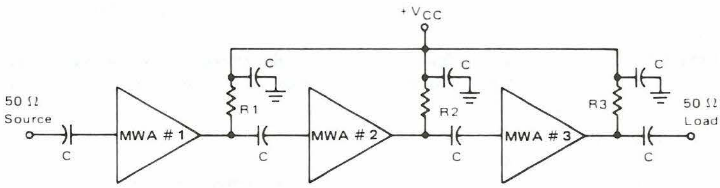
The 50 Ω input/output impedance levels of the MWA hybrids are most easily preserved on a circuit board by using 50 Ω microstrip transmission lines. Figure 28 is an example of a circuit board layout which utilizes microstrip transmission lines in conjunction with other sound RF construction techniques.

The characteristic impedance and corresponding line width of the microstrip are a function of the circuit board dielectric constant and thickness. The table lists appropriate line widths for 50 Ω microstrip lines on commonly used circuit board materials.

MATERIAL TYPE	DIELECTRIC CONSTANT	DIELECTRIC THICKNESS INCHES	LINE WIDTH INCHES
Teflon-Fiberglass	2.5	0.03125 0.0625	0.090 0.180
Fiberglass Epoxy	5.0	0.0625	0.100

As in all good RF circuit designs, care should be taken to minimize parasitic lead inductances and to provide adequate grounding.

FIGURE 29 — TYPICAL CASCADE



All Capacitors (C) are 0.018 μF Chip Capacitors

Cascading

The inherent stability of the MWA hybrid modules makes possible the cascading of two or more units with no oscillatory problems. Figure 29 shows a typical 3 hybrid cascade with measured data for 400 MHz and 1000 MHz hybrids.

	Cascade 1	Cascade 2
Frequency Range	0.25 to 400 MHz	0.25 to 1000 MHz
Gain	43.5 dB	20.5 dB
Gain Flatness	± 1.0 dB	± 0.75 dB
Input VSWR	2.0:1	2.4:1
Output VSWR	1.2:1	2.1:1
V_{CC} Supply	12 Vdc	33 Vdc
I Supply	44 mAdc	150 mAdc
MWA #1	MWA110	MWA320
MWA #2	MWA110	MWA330
MWA #3	MWA120	MWA330
R1	1000 Ω	1000 Ω
R2	1000 Ω	500 Ω
R3	300 Ω	500 Ω

MWA210
MWA220
MWA230

CASE 31A-01, STYLE 2

GENERAL PURPOSE HYBRID AMPLIFIERS

MAXIMUM RATINGS

Rating	Symbol	Value			Unit
		MWA210	MWA220	MWA230	
RF Input Power	P_{in}	100			mW
DC Supply Current	I_D	25	55	100	mA
Maximum Case Temperature	T_C	125			°C
Storage Temperature Range	T_{stg}	−65 to +200			°C
OPERATING CONDITIONS					
Device Voltage	V_D	1.75	3.2	4.4	Vdc
Device Current	I_D	10	25	60	mAdc
Decoupling Impedance	Z_D	1000	1000	330	Ω

ELECTRICAL CHARACTERISTICS (T_C = −25 to +100°C, 50 Ω system and specified operating conditions.)

Characteristic		Symbol	Min	Typ	Max	Unit
Frequency Range		BW	0.1	—	600	MHz
Power Gain		G_p	9.0	10	—	dB
Response Flatness		F	—	0	±1.0	dB
Input VSWR	MWA210/220	—	—	—	2.5:1	—
	MWA230	—	—	—	3:1	—
Output VSWR	MWA210/220/230	—	—	—	2.5:1	—
Output @ 1.0 dB Gain Compression						dBm
	MWA210		—	+1.5	—	
	MWA220		—	+10.5	—	
	MWA230		—	+18.5	—	
Noise Figure		NF				dB
	MWA210		—	6.0	—	
	MWA220		—	6.5	—	
	MWA230		—	7.5	—	
Reverse Isolation		P_{RI}				dB
	MWA210		—	13.5	—	
	MWA220		—	14.5	—	
	MWA230		—	12.9	—	
Harmonic Output		d_{so}				dB
	MWA210 (P_{out} = −9.0 dBm)		—	−29	—	
	MWA220 (P_{out} = 0 dBm)		—	−36	—	
	MWA230 (P_{out} = +10 dBm)		—	−36	—	

FIGURE 1 – DEVICE VOLTAGE versus DEVICE CURRENT

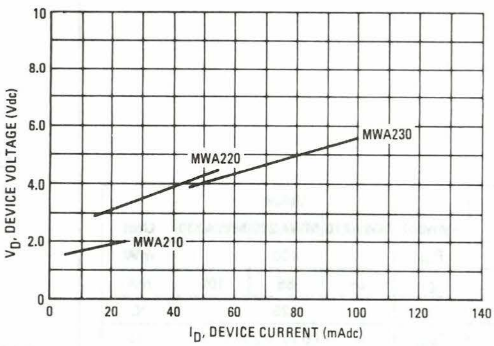


FIGURE 2 – DEVICE CURRENT versus CASE TEMPERATURE

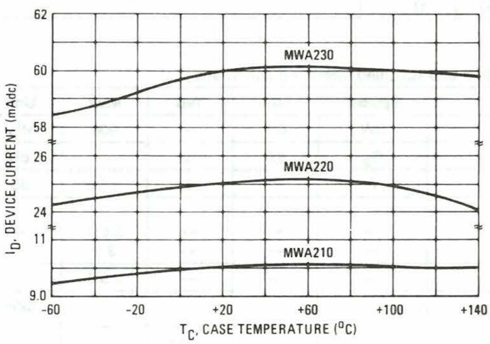


FIGURE 3 – POWER GAIN versus FREQUENCY

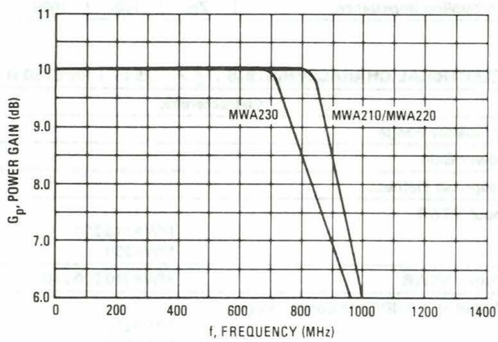


FIGURE 4 – POWER GAIN versus DEVICE CURRENT
f = 600 MHz

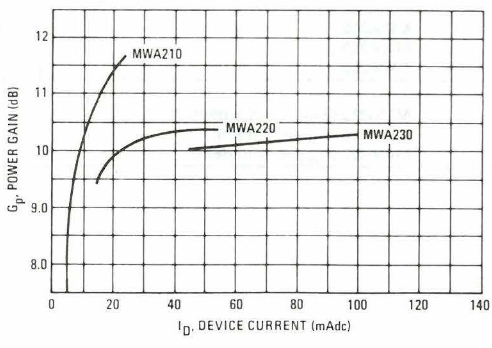


FIGURE 5 – POWER GAIN versus CASE TEMPERATURE
f = 100 MHz

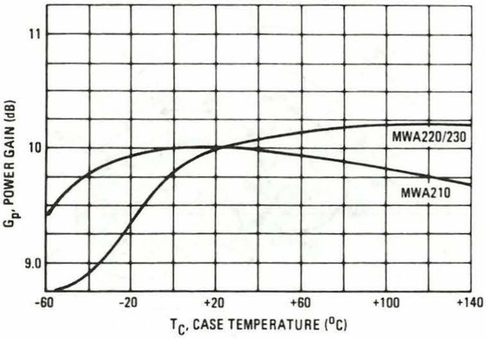


FIGURE 6 – POWER GAIN versus CASE TEMPERATURE
f = 600 MHz

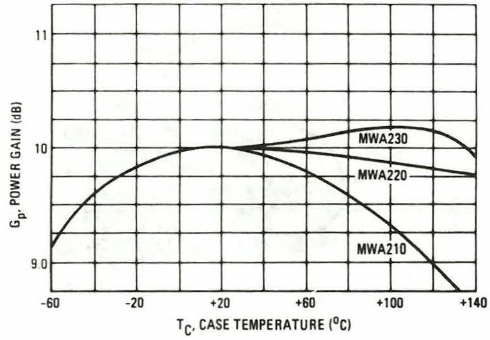


FIGURE 7 – VSWR versus FREQUENCY
MWA210

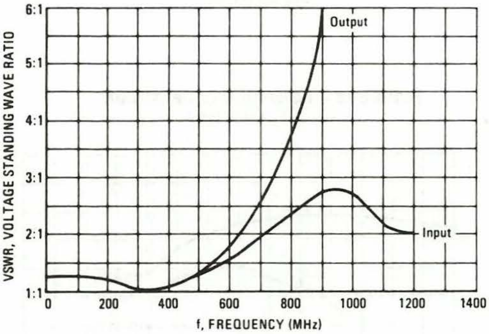


FIGURE 8 – VSWR versus FREQUENCY
MWA220

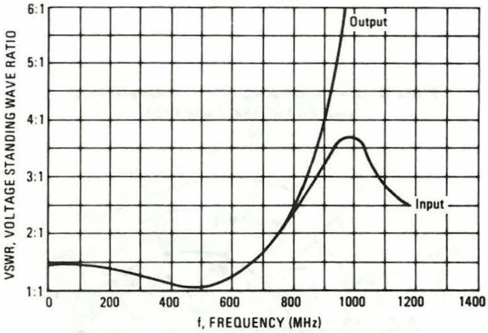
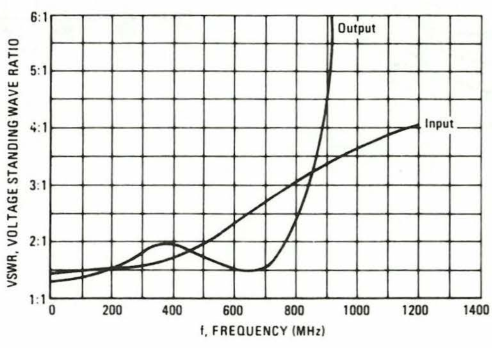


FIGURE 9 – VSWR versus FREQUENCY
MWA230



7

FIGURE 10 – INPUT AND OUTPUT IMPEDANCE versus FREQUENCY MWA210

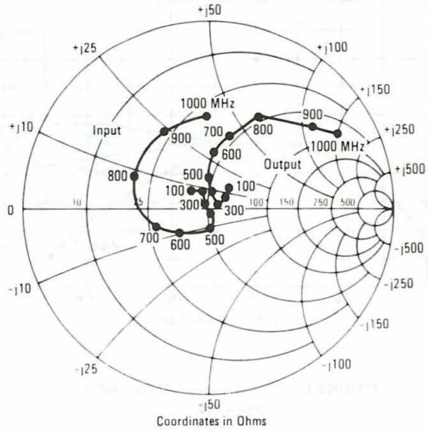


FIGURE 11 – INPUT AND OUTPUT IMPEDANCE versus FREQUENCY MWA220

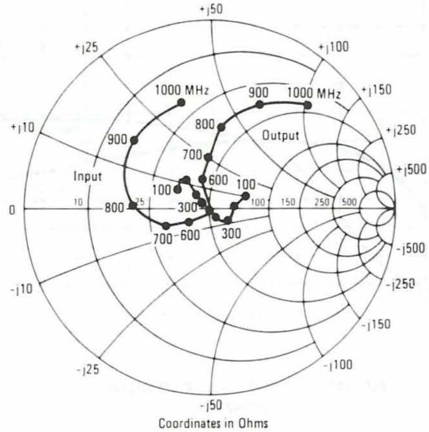


FIGURE 12 – INPUT AND OUTPUT IMPEDANCE versus FREQUENCY MWA230

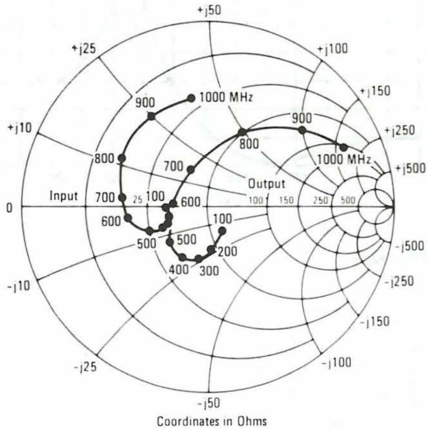
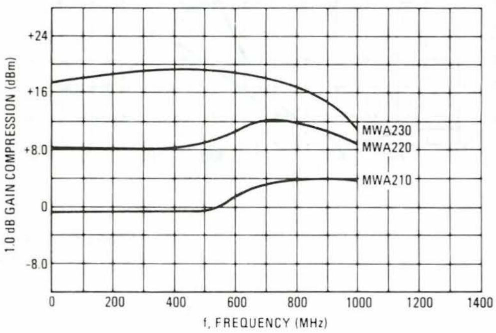


FIGURE 13 – 1.0 dB GAIN COMPRESSION versus FREQUENCY



7

FIGURE 14 — 1.0 dB GAIN COMPRESSION versus DEVICE CURRENT f = 600 MHz

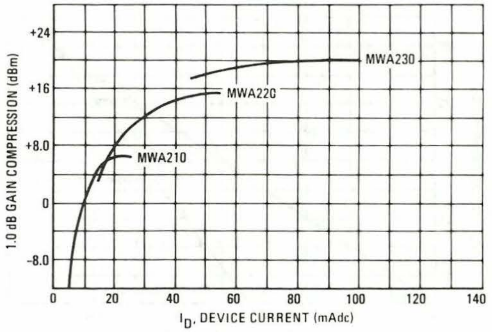


FIGURE 15 — 1.0 dB GAIN COMPRESSION versus CASE TEMPERATURE f = 600 MHz

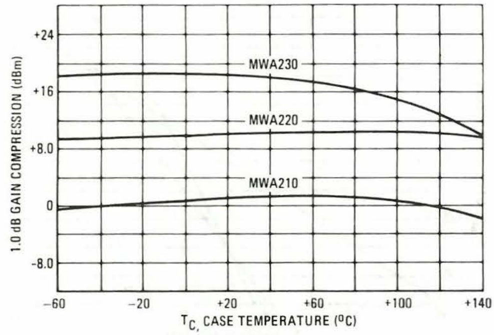


FIGURE 16 — NOISE FIGURE versus FREQUENCY

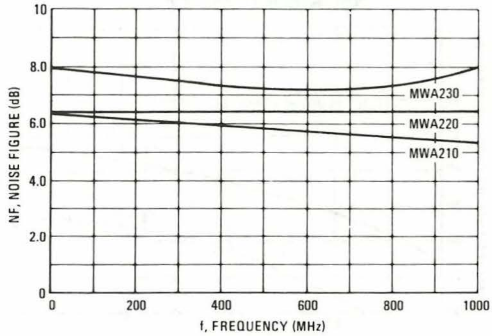


FIGURE 17 — REVERSE ISOLATION versus FREQUENCY

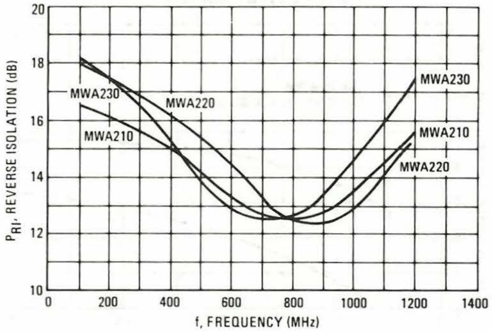


FIGURE 18 — SECOND HARMONIC OUTPUT versus FREQUENCY

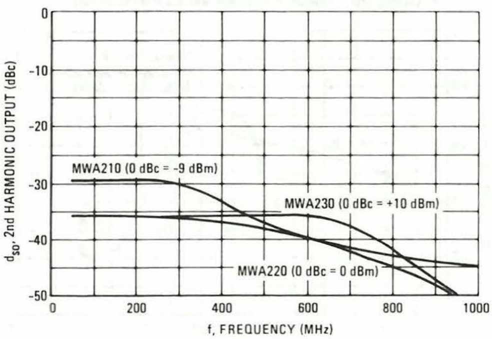
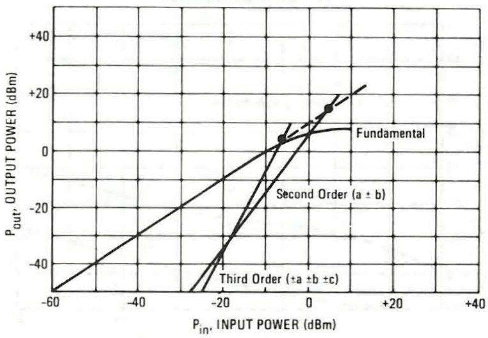


FIGURE 19 — SECOND AND THIRD ORDER INTERCEPT MWA210



7

FIGURE 20 – SECOND AND THIRD ORDER INTERCEPT MWA220

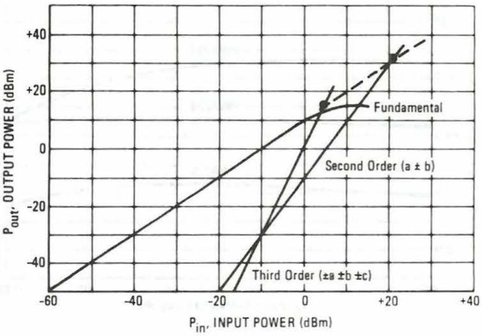


FIGURE 21 – SECOND AND THIRD ORDER INTERCEPT MWA230

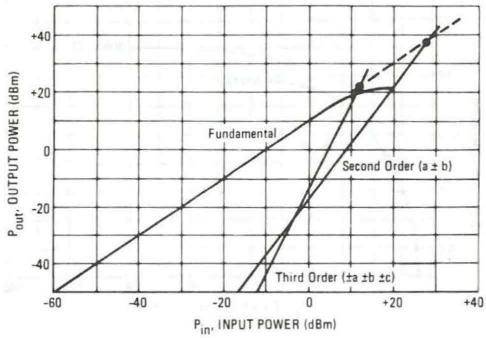


FIGURE 22 – INTERMODULATION DISTORTION versus POWER OUTPUT MWA210

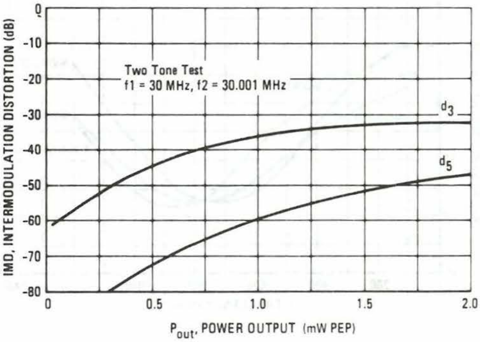


FIGURE 23 – INTERMODULATION DISTORTION versus POWER OUTPUT MWA220

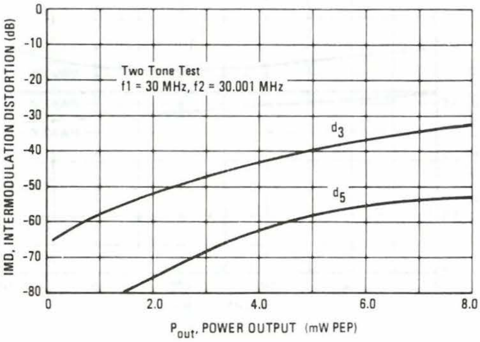


FIGURE 24 – INTERMODULATION DISTORTION versus POWER OUTPUT MWA230

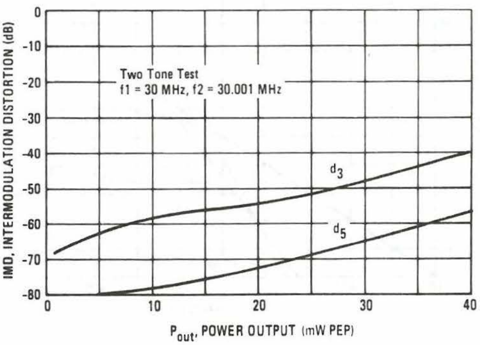
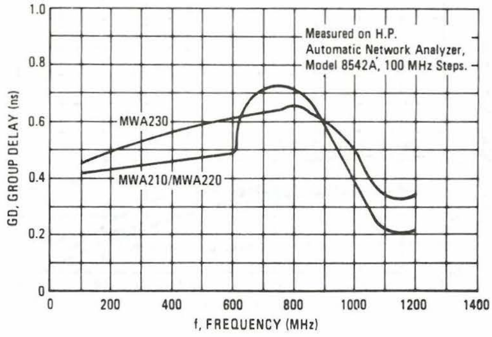


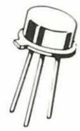
FIGURE 25 – GROUP DELAY versus FREQUENCY



7

MWA310
MWA320
MWA330

CASE 31A-01, STYLE 2



GENERAL PURPOSE HYBRID AMPLIFIERS

MAXIMUM RATINGS

Rating	Symbol	Value MWA310	MWA320	MWA330	Unit
RF Input Power	P_{in}	100			mW
DC Supply Current	I_D	25	55	100	mA
Maximum Case Temperature	T_C	125			°C
Storage Temperature Range	T_{stg}	−65 to +200			°C
OPERATING CONDITIONS					
Device Voltage	V_D	1.6	2.9	4.0	Vdc
Device Current	I_D	10	25	60	mAdc
Decoupling Impedance	Z_D	1000	1000	330	Ω

ELECTRICAL CHARACTERISTICS (T_C = −25 to +80°C, 50 Ω system and specified operating conditions.)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	0.1	—	1000	MHz
Power Gain	G_p				dB
MWA310/320		7.0	8.0	—	
MWA330		—	6.2	—	
Response Flatness	F	—	0	±1.0	dB
Input VSWR	—	—	—	3:1	—
Output VSWR	—	—	—	3:1	—
Output @ 1.0 dB Gain Compression					dBm
MWA310		—	+3.5	—	
MWA320		—	+11.5	—	
MWA330		—	+15.2	—	
Noise Figure	NF				dB
MWA310		—	6.5	—	
MWA320		—	6.7	—	
MWA330		—	9.0	—	
Reverse Isolation	P_{RI}				dB
MWA310		—	10.4	—	
MWA320		—	10.4	—	
MWA330		—	9.0	—	
Harmonic Output	d_{so}				dB
MWA310 (P_{out} = −9.0 dBm)		—	−30	—	
MWA320 (P_{out} = 0 dBm)		—	−38	—	
MWA330 (P_{out} = +10 dBm)		—	−35	—	

FIGURE 1 — DEVICE VOLTAGE versus DEVICE CURRENT

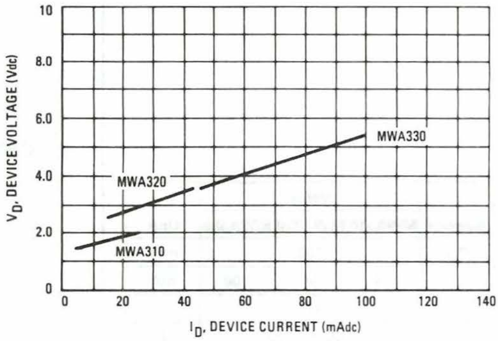


FIGURE 2 — DEVICE CURRENT versus CASE TEMPERATURE

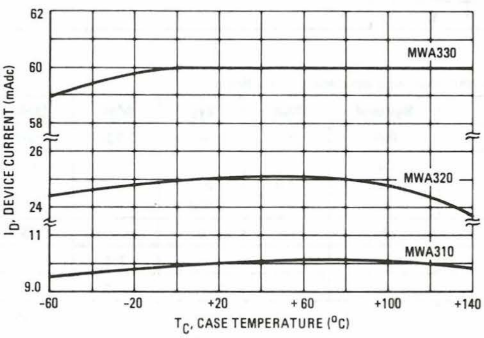


FIGURE 3 — POWER GAIN versus FREQUENCY

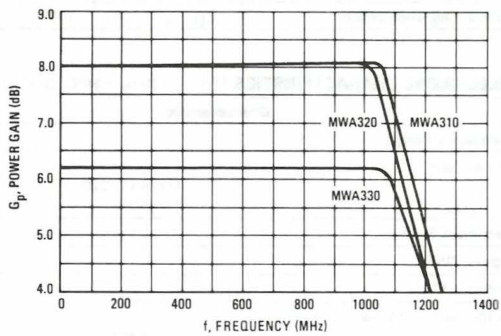


FIGURE 4 — POWER GAIN versus DEVICE CURRENT
f = 1000 MHz

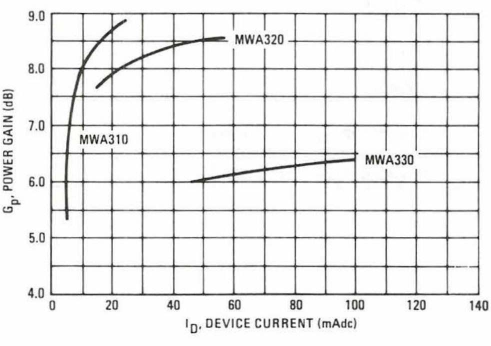


FIGURE 5 – POWER GAIN versus CASE TEMPERATURE
f = 100 MHz

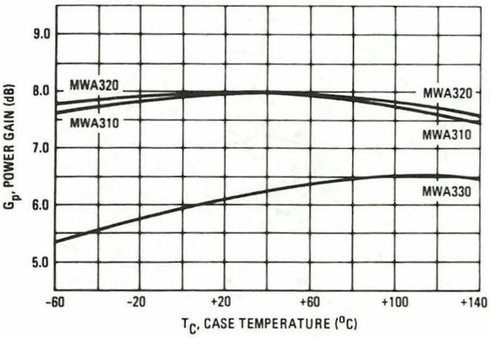


FIGURE 6 – POWER GAIN versus CASE TEMPERATURE
f = 1000 MHz

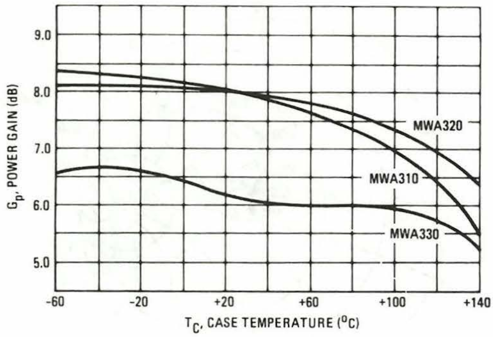


FIGURE 7 – VSWR versus FREQUENCY
MWA310

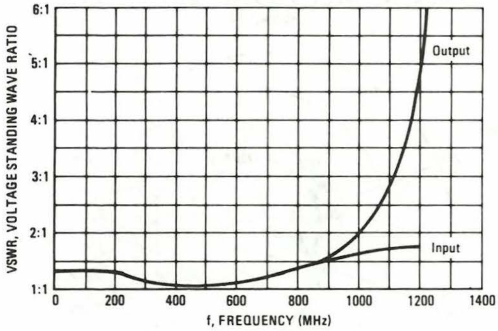


FIGURE 8 – VSWR versus FREQUENCY
MWA320

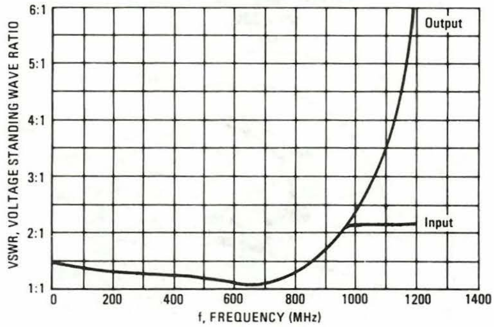


FIGURE 9 – VSWR versus FREQUENCY
MWA330

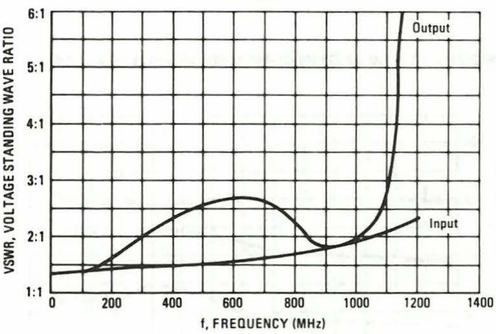


FIGURE 10 – INPUT IMPEDANCE versus FREQUENCY
MWA310

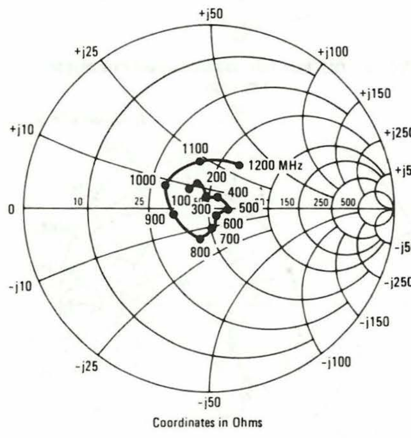
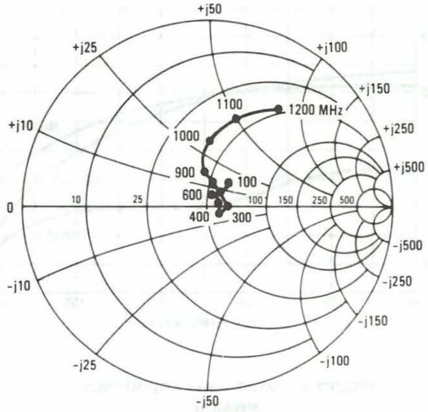


FIGURE 11 – OUTPUT IMPEDANCE versus FREQUENCY MWA310



Coordinates in Ohms

FIGURE 12 – INPUT IMPEDANCE versus FREQUENCY MWA320

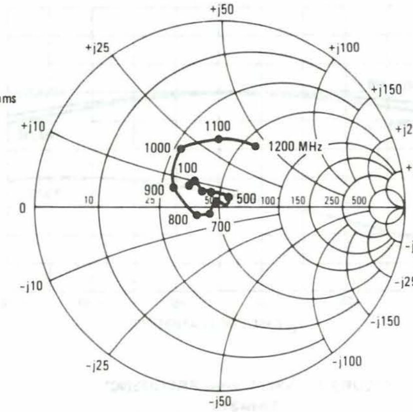
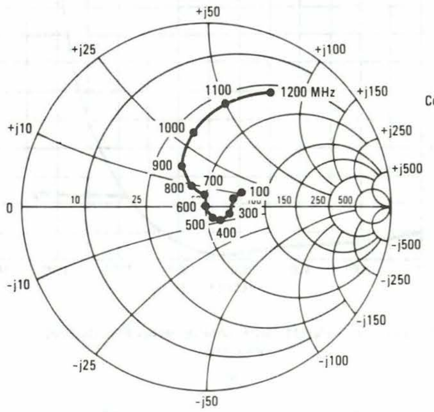


FIGURE 13 – OUTPUT IMPEDANCE versus FREQUENCY MWA320



Coordinates in Ohms

FIGURE 14 – INPUT IMPEDANCE versus FREQUENCY MWA330

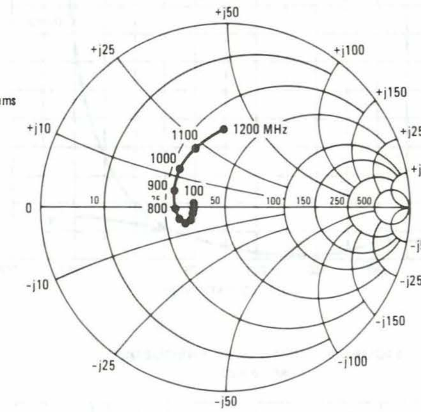


FIGURE 15 – OUTPUT IMPEDANCE versus FREQUENCY MWA330

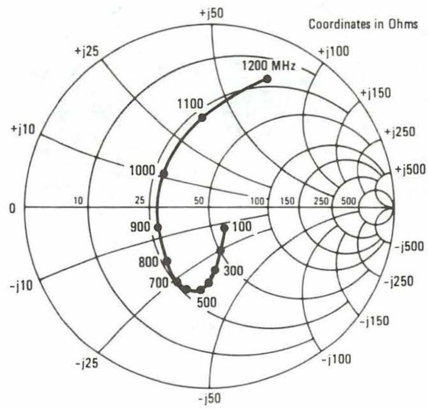
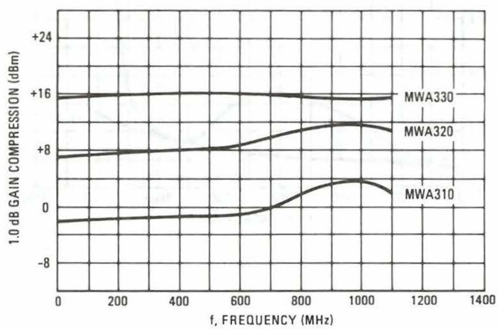


FIGURE 16 – 1.0 dB GAIN COMPRESSION versus FREQUENCY



7

FIGURE 17 — 1.0 dB GAIN COMPRESSION versus DEVICE CURRENT f = 1000 MHz

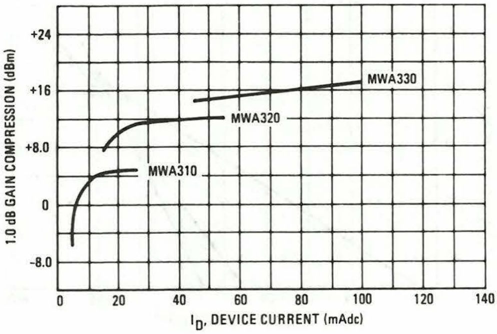


FIGURE 18 — 1.0 dB GAIN COMPRESSION versus CASE TEMPERATURE f = 1000 MHz

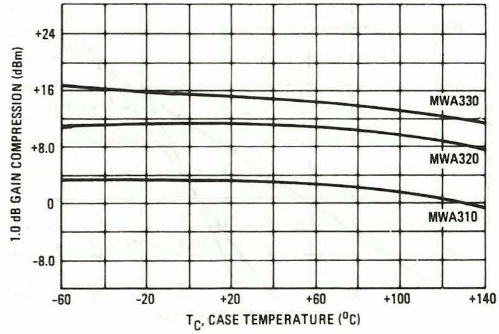


FIGURE 19 — NOISE FIGURE versus FREQUENCY

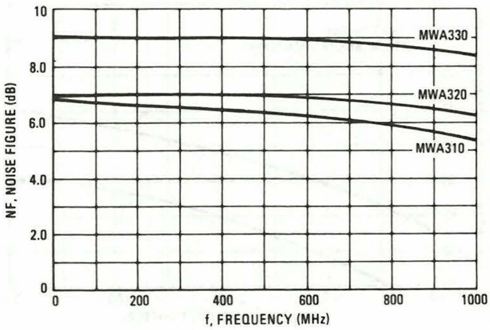


FIGURE 20 — REVERSE ISOLATION versus FREQUENCY

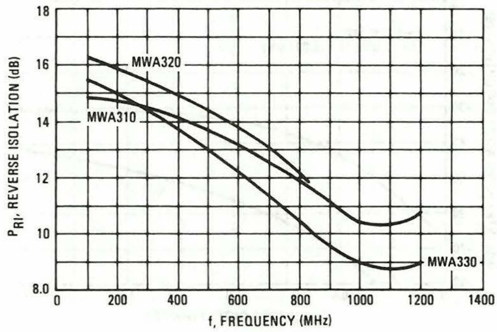


FIGURE 21 — SECOND HARMONIC OUTPUT versus FREQUENCY

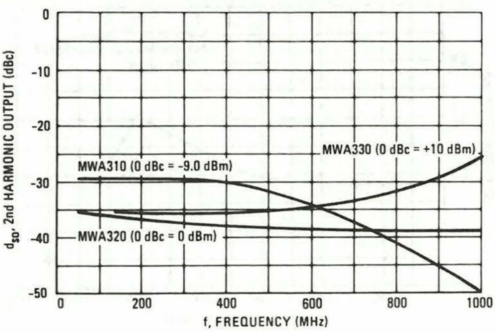
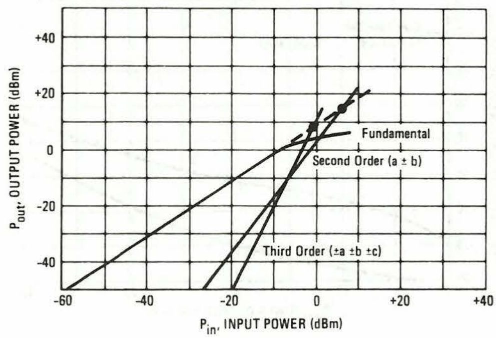


FIGURE 22 — SECOND AND THIRD ORDER INTERCEPT MWA310



7

FIGURE 23 – SECOND AND THIRD ORDER INTERCEPT
MWA320

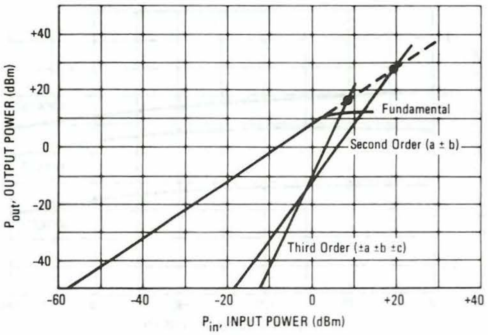


FIGURE 24 – SECOND AND THIRD ORDER INTERCEPT
MWA330

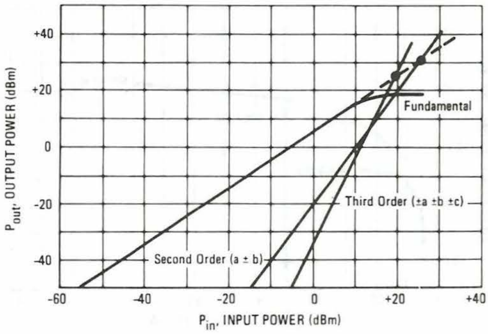


FIGURE 25 – INTERMODULATION DISTORTION versus POWER OUTPUT
MWA310

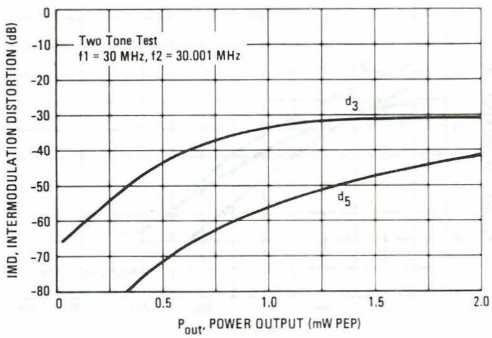


FIGURE 26 – INTERMODULATION DISTORTION versus POWER OUTPUT
MWA320

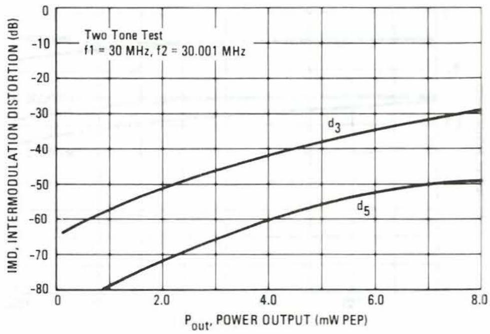


FIGURE 27 – INTERMODULATION DISTORTION versus POWER OUTPUT
MWA330

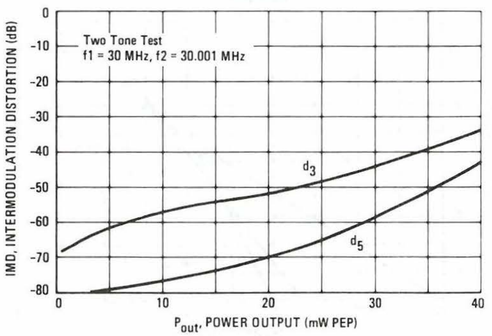
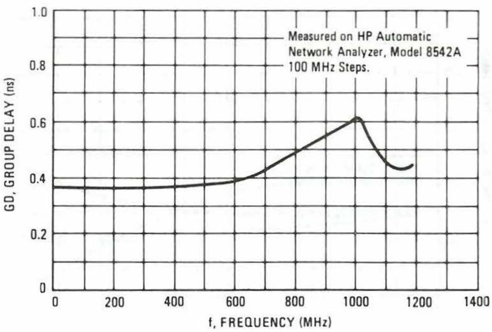


FIGURE 28 – GROUP DELAY versus FREQUENCY
MWA310/MWA320/MWA330



7

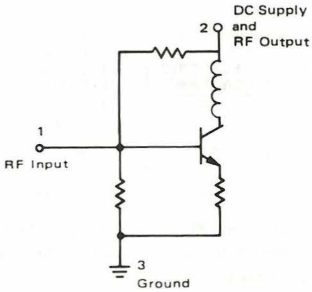
MWA SERIES HYBRID AMPLIFIER APPLICATIONS INFORMATION

The MWA series hybrid amplifiers are designed for wideband general purpose applications in 50 Ω systems. Fully cascadable for any gain combination, operable at voltages as low as 3 Vdc, and external control of the low frequency corner make the MWA amplifiers extremely versatile gain blocks.

Basic Circuit Configuration

Figure 29 shows the basic internal circuit. It is important to note that the specified operating conditions of voltage, current, and external decoupling impedance must be applied to the units in order to achieve the published electrical characteristics.

FIGURE 29 — INTERNAL CIRCUIT



Amplifier Application

The circuit schematic for a simple amplifier design is shown in Figure 30. External to the MWA hybrid amplifier the only components required are:

Decoupling elements — Bypass Capacitor
Decoupling Impedance
(resistor/inductor)
DC Blocking Capacitors at the RF input and output.

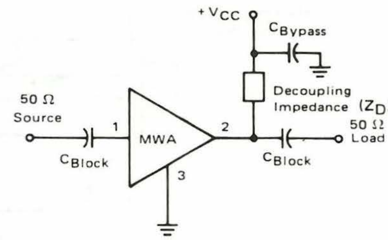
External Decoupling Impedance

In all cases the external bias (decoupling elements) must present an impedance which is large compared to the 50 Ω load impedance to minimize RF gain reduction. The loss in gain due to the decoupling impedance is given by the equation:

$$\text{Loss} = 20\ \text{Log}\ \frac{Z_D}{Z_D + 25}\ \text{dB}$$

where Z_D = decoupling impedance in ohms. For example, if Z_D = 1 kΩ, Loss = 0.214 dB.

FIGURE 30 — AMPLIFIER SCHEMATIC DIAGRAM



Supply Voltage

The value of the external decoupling resistive impedance (R_D) determines the supply voltage ($+V_{CC}$) and is determined by the following equation:

$$V_{CC} = R_D \times I_D + V_D$$

where I_D and V_D are the device current and voltage stated in the data sheet. For example, for MWA110,

$$I_D = 10\ \text{mA}$$
$$V_D = 2.9\ \text{V}$$

and, if R_D = 330 Ω, then

$$V_{CC} = 6.2\ \text{V}$$

More commonly V_{CC} is predetermined and R_D may be calculated from:

$$R_D = \frac{V_{CC} - V_D}{I_D}$$

If an RF choke is used for decoupling, then the supply voltage (V_{CC}) required is equal to the device voltage (V_D).

Low Frequency Response

The value of the blocking capacitors determines the low frequency response of the amplifier. The following expression is used to determine the blocking capacitor value to yield a desired 3 dB low frequency corner (f_{LFC}).

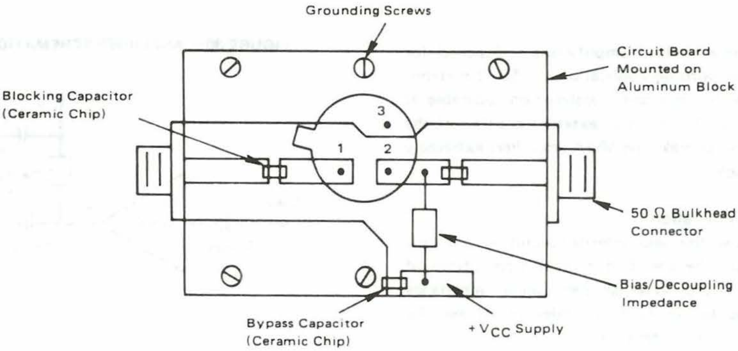
$$C_{Block}(\text{Farads}) = \frac{1}{100\ \pi\ f_{LFC}(\text{Hz})}$$

Bypass Capacitor

The reactive impedance of the bypass capacitor should be small compared to the impedance of the decoupling element at the lowest frequency of operation.

7

FIGURE 31 – TEST FIXTURE



Note: The circuitry indicated is on the underside of the printed circuit board with sockets for the amplifier pins. The case of the amplifier should contact the printed circuit board top surface to ensure effective RF grounding.

Text Fixture

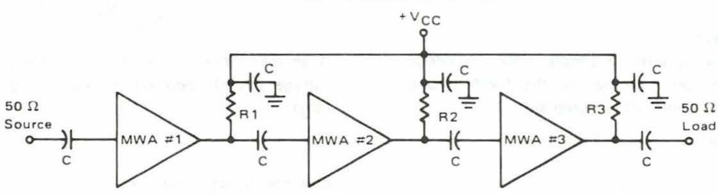
The 50 Ω input/output impedance levels of the MWA hybrids are most easily preserved on a circuit board by using 50 Ω microstrip transmission lines. Figure 31 is an example of a circuit board layout which utilizes microstrip transmission lines in conjunction with other sound RF construction techniques.

The characteristic impedance and corresponding line width of the microstrip are a function of the circuit board dielectric constant and thickness. The table lists appropriate line widths for 50 Ω microstrip lines on commonly used circuit board materials.

MATERIAL TYPE	DIELECTRIC CONSTANT	DIELECTRIC THICKNESS INCHES	LINE WIDTH INCHES
Teflon-Fiberglass	2.5	0.03125 0.0625	0.090 0.180
Fiberglass-Epoxy	5.0	0.0625	0.100

As in all good RF circuit designs, care should be taken to minimize parasitic lead inductances and to provide adequate grounding.

FIGURE 32 – TYPICAL CASCADE



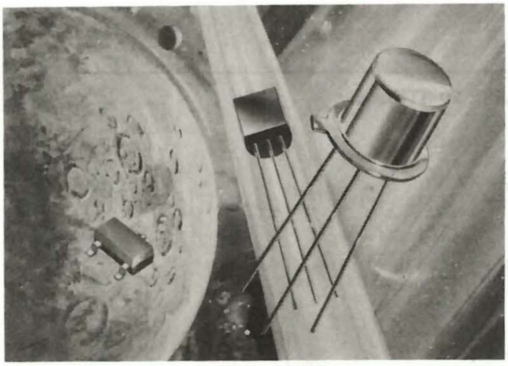
All Capacitors (C) are 0.018 μF Chip Capacitors

Cascading

The inherent stability of the MWA hybrid modules makes possible the cascading of two or more units with no oscillatory problems. Figure 32 shows a typical 3 hybrid cascade with measured data for 400 MHz and 1000 MHz hybrids.

	Cascade 1	Cascade 2
Frequency Range	0.25 to 400 MHz	0.25 to 1000 MHz
Gain	43.5 dB	20.5 dB
Gain Flatness	± 1.0 dB	± 0.75 dB
Input VSWR	2.0:1	2.4:1
Output VSWR	1.2:1	2.1:1
V_{CC} Supply	12 Vdc	33 Vdc
I Supply	44 mAdc	150 mAdc
MWA #1	MWA110	MWA320
MWA #2	MWA110	MWA330
MWA #3	MWA120	MWA330
R1	1000 Ω	1000 Ω
R2	1000 Ω	500 Ω
R3	300 Ω	500 Ω

7



The following pages contain information on the various packages referenced on the individual data sheets. Information includes: a picture of the package, dimensions in both millimeters and inches, the various pinout configurations (styles), a cross reference for Case numbers, "old" JEDEC "TO" numbers, and the new JEDEC "TO" designation.

Additionally, abstracts of available application notes are provided. Please contact your local sales representative for those desired.

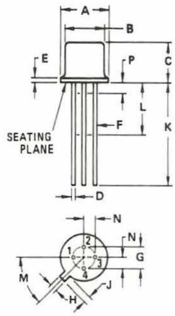
Package Outline Dimensions and Application Information

8

Package Outline Dimensions

Dimensions are in inches unless otherwise noted.

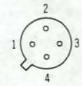
CASE 20-03 TO-72 (TO-206AF)



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	–	0.76	–	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

ALL JEDEC dimensions and notes apply

CASE 20 STYLES



STYLE 1
PIN 1. SOURCE
2. DRAIN
3. GATE
4. CASE LEAD

STYLE 2
PIN 1. SOURCE
2. GATE
3. DRAIN
4. SUBSTRATE AND CASE LEAD

STYLE 3
PIN 1. DRAIN
2. SOURCE
3. GATE
4. CASE LEAD

STYLE 4
PIN 1. SOURCE
2. GATE
3. DRAIN
4. GATE 2 – SUBSTRATE AND CASE

STYLE 5
PIN 1. SOURCE
2. GATE 1
3. DRAIN
4. CASE

STYLE 6
PIN 1. DRAIN
2. SOURCE AND SUBSTRATE
3. GATE
4. SOURCE AND SUBSTRATE

STYLE 7
PIN 1. DRAIN
2. SOURCE
3. GATE
4. CASE AND SUBSTRATE

STYLE 8
PIN 1. EMITTER 2
2. BASE 1
3. COLLECTOR
4. EMITTER 1 BASE 2

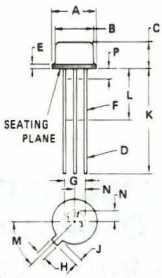
STYLE 9
PIN 1. DRAIN
2. GATE 2
3. GATE 1
4. SOURCE, SUBSTRATE AND CASE

STYLE 10
PIN 1. EMITTER
2. BASE
3. COLLECTOR
4. CASE

STYLE 11
PIN 1. EMITTER
2. CATHODE
3. COLLECTOR
4. ANODE

NOTE:
1. ALL RULES AND NOTES WITH TO-72 OUTLINE SHALL APPLY

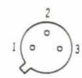
CASE 22-03 TO-18 (TO-206AA)



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC notes and dimensions apply.

CASE 22 STYLES



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

STYLE 2:
PIN 1. SOURCE,SUBSTRATE AND CASE
2. GATE
3. DRAIN

STYLE 3:
PIN 1. SOURCE
2. DRAIN
3. GATE

STYLE 4:
PIN 1. SOURCE
2. DRAIN
3. GATE &CASE

STYLE 5:
PIN 1. EMITTER
2. BASE 1
3. BASE 2

STYLE 6:
PIN 1. CATHODE
2. GATE
3. ANODE

STYLE 7:
PIN 1. ANODE
2. BASE
3. CATHODE

STYLE 8:
PIN 1. GATE
2. ANODE 1
3. ANODE 2

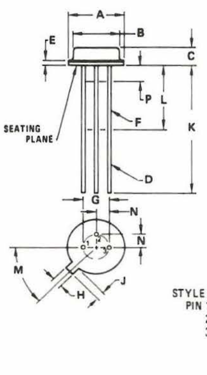
STYLE 9:
PIN 1. ANODE 2
2. ANODE 1
3. GATE (CONNECTED TO CASE)

STYLE 10:
PIN 1. BASE
2. EMITTER
3. BASE

STYLE 11:
PIN 1. DRAIN
2. GATE
3. SOURCE, SUBSTRATE

STYLE 12:
PIN 1. SOURCE
2. GATE
3. DRAIN (CASE)

CASE 26-03 TO-46 (TO-206AB)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	1.65	2.16	0.065	0.085
D	0.406	0.533	0.016	0.021
E	–	1.02	–	0.040
F	0.305	0.483	0.012	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC dimensions and notes apply

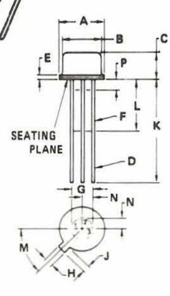
CASE 27-02 TO-52 (TO-206AC)

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

STYLE 2:
PIN 1. DRAIN
2. SOURCE
3. GATE & CASE

STYLE 3:
PIN 1. EMITTER
2. BASE
3. BASE 2

STYLE 4:
PIN 1. SOURCE
2. DRAIN
3. GATE & CASE

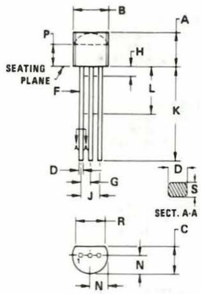


DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	2.92	3.81	0.115	0.150
D	–	0.533	–	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC dimensions and notes apply

PACKAGE OUTLINE DIMENSIONS (continued)

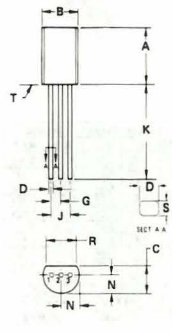
CASE 29-02 TO-92 (TO-226AA)



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.32	5.33	0.170	0.210
B	4.44	5.21	0.175	0.205
C	3.18	4.19	0.125	0.165
D	0.41	0.56	0.016	0.022
F	0.41	0.48	0.016	0.019
G	1.14	1.40	0.045	0.055
H	–	2.54	–	0.100
J	2.41	2.67	0.095	0.105
K	12.70	–	0.500	–
L	6.35	–	0.250	–
N	2.03	2.67	0.080	0.105
P	2.92	–	0.115	–
R	3.43	–	0.135	–
S	0.36	0.41	0.014	0.016

All JEDEC dimensions and notes apply.

CASE 29-03 TO-226AE



NOTES:

1. DIMENSIONS -A- AND -B- ARE DATUMS.
2. -T- IS SEATING PLANE.
3. POSITIONAL TOLERANCE FOR LEADS:
   ⌖ | Ø 0.10 (0.004) Ⓜ | T | A Ⓜ | B Ⓜ
4. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	7.37	7.87	0.290	0.310
B	4.44	5.21	0.175	0.205
C	3.18	4.19	0.125	0.165
D	0.46	0.61	0.018	0.024
G	1.27 BSC		0.050 BSC	
J	2.54 BSC		0.100 BSC	
K	12.70	–	0.500	–
N	2.03	2.92	0.080	0.115
R	3.43	–	0.135	–
S	0.46	0.61	0.018	0.024

CASE 29 STYLES

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

STYLE 2:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

STYLE 3:
PIN 1. ANODE
2. ANODE
3. CATHODE

STYLE 4:
PIN 1. CATHODE
2. CATHODE
3. ANODE

STYLE 5:
PIN 1. DRAIN
2. SOURCE
3. GATE

STYLE 6:
PIN 1. GATE
2. SOURCE & SUBSTRATE
3. DRAIN

STYLE 7:
PIN 1. SOURCE
2. DRAIN
3. GATE

STYLE 8:
PIN 1. DRAIN
2. GATE
3. SOURCE & SUBSTRATE

STYLE 9:
PIN 1. BASE 1
2. EMITTER
3. BASE 2

STYLE 10:
PIN 1. CATHODE
2. GATE
3. ANODE

STYLE 11:
PIN 1. ANODE
2. CATHODE & ANODE
3. CATHODE

STYLE 12:
PIN 1. MAIN TERMINAL 1
2. GATE
3. MAIN TERMINAL 2

STYLE 13:
PIN 1. ANODE 1
2. GATE
3. CATHODE 2

STYLE 14:
PIN 1. EMITTER
2. COLLECTOR
3. BASE

STYLE 15:
PIN 1. ANODE 1
2. CATHODE
3. ANODE 2

STYLE 16:
PIN 1. ANODE
2. GATE
3. CATHODE

STYLE 17:
PIN 1. COLLECTOR
2. BASE
3. EMITTER

STYLE 18:
PIN 1. ANODE
2. CATHODE
3. NOT CONNECTED

STYLE 19:
PIN 1. GATE
2. ANODE
3. CATHODE

STYLE 20:
PIN 1. NOT CONNECTED
2. CATHODE
3. ANODE

STYLE 21:
PIN 1. COLLECTOR
2. EMITTER
3. BASE

STYLE 22:
PIN 1. SOURCE
2. GATE
3. DRAIN

STYLE 23:
PIN 1. GATE
2. SOURCE
3. DRAIN

STYLE 24:
1. EMITTER
2. COLLECTOR/ANODE
3. CATHODE

STYLE 25:
1. MT 1
2. GATE
3. MT 2

STYLE 26:
PIN 1. V_{CC}
2. GROUND 2
3. OUTPUT

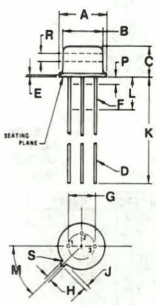
STYLE 27:
PIN 1. MT
2. SUBSTRATE
3. MT

STYLE 28:
PIN 1. CATHODE
2. ANODE
3. GATE

STYLE 29:
PIN 1. NOT CONNECTED
2. ANODE
3. CATHODE

STYLE 30:
PIN 1. DRAIN
2. GATE
3. SOURCE

CASE 31-03 TO-5 (TO-205AA)



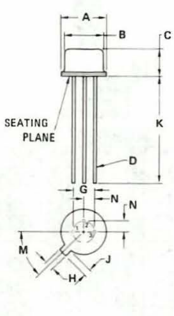
STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

STYLE 2:
PIN 1. CATHODE
2. GATE
3. ANODE

STYLE 3:
PIN 1. GATE
2. CATHODE
3. ANODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	5.08 BSC		0.200 BSC	
H	0.711	0.864	0.028	0.034
J	0.734	1.14	0.029	0.045
K	38.10	44.45	1.500	1.750
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	——		——	
P	–	1.27	–	0.050
R	2.54	–	0.100	–
S	–	0.25	–	0.010

CASE 31A-01



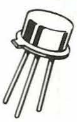
STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

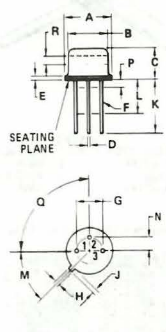
STYLE 2:
PIN 1. INPUT
2. OUTPUT
3. GROUND

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.57	0.150	0.180
D	0.41	0.48	0.016	0.019
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

NOTE:
1. LEADS WITHIN 0.36 mm (0.014) DIA OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.

CASE 79-02 TO-39 (TO-205AD)





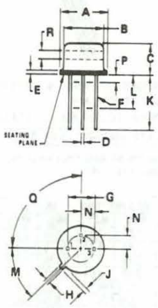
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

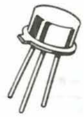
All JEDEC dimensions and notes apply.

8

PACKAGE OUTLINE DIMENSIONS (continued)

CASE 79-03

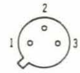




DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	9.02	9.30	0.355	0.366
B	8.00	8.51	0.315	0.335
C	4.19	4.57	0.165	0.180
D	0.43	0.53	0.017	0.021
E	0.43	0.89	0.017	0.035
F	0.41	0.48	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.71	0.86	0.028	0.034
J	0.74	1.02	0.029	0.040
K	12.70	–	0.500	–
M	45° NOM		45° NOM	
N	2.54 TYP		0.100 TYP	
Q	90° NOM		90° NOM	

CASE 79 STYLES

PIN 1. INPUT
2. OUTPUT
3. GROUND



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

STYLE 2:
PIN 1. DRAIN
2. SOURCE
3. GATE

STYLE 3:
PIN 1. CATHODE
2. GATE
3. ANODE

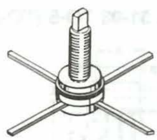
STYLE 4:
PIN 1. MAIN TERM. 1
2. GATE
3. MAIN TERM. 2

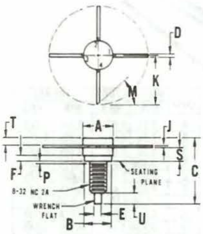
STYLE 5:
PIN 1. COLLECTOR
2. BASE
3. EMITTER

STYLE 6:
PIN 1. SOURCE
2. GATE
3. DRAIN
(CASE)

NOTES:
1. ALL RULES AND NOTES ASSOCIATED WITH TO-39 OUTLINE SHALL APPLY.

CASE 244A-01



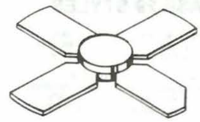


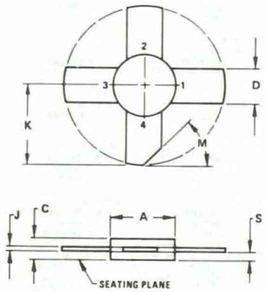
STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

STYLE 2:
PIN 1. COMMON
2. OUTPUT
3. COMMON
4. INPUT

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	7.06	7.26	0.278	0.286
B	6.20	6.50	0.244	0.256
C	15.24	16.51	0.600	0.650
D	0.66	0.86	0.026	0.034
E	1.40	1.65	0.055	0.065
F	1.52	–	0.060	–
J	0.10	0.15	0.004	0.006
K	11.17	–	0.440	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
S	2.74	3.35	0.108	0.132
T	1.40	1.78	0.055	0.070
U	2.92	3.68	0.115	0.145

CASE 249-05





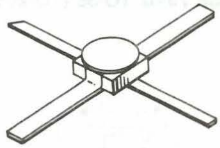
STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

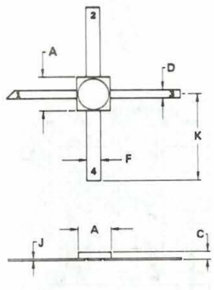
STYLE 2:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

SEATING PLANE = GROUND AND IS CONNECTED TO PIN 1 AND PIN 3.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	7.06	7.26	0.278	0.286
C	2.84	3.45	0.112	0.136
D	5.46	5.97	0.215	0.235
J	0.08	0.18	0.003	0.007
K	11.05	–	0.435	–
M	45° NOM		45° NOM	
S	1.40	1.65	0.055	0.065

CASE 303-01





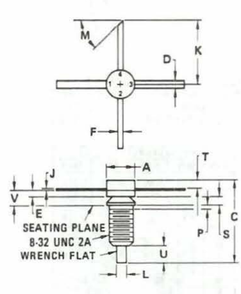
STYLE 1:
PIN 1. COLLECTOR
2. EMITTER
3. BASE
4. EMITTER

STYLE 2:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. BASE

NOTE:
1. DIMENSION K APPLIES TO ALL LEADS.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	2.29	2.67	0.090	0.105
C	0.89	1.40	0.035	0.055
D	0.41	0.61	0.016	0.024
F	0.89	1.09	0.035	0.043
J	0.08	0.15	0.003	0.006
K	4.45	5.84	0.175	0.230

CASE 305-01

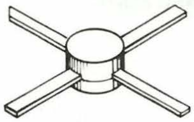


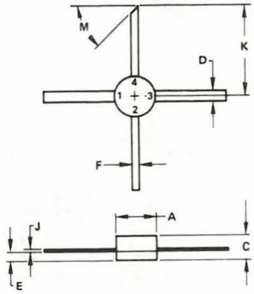
STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.08	5.59	0.200	0.220
C	13.97	16.26	0.550	0.640
D	1.40	1.65	0.055	0.065
E	1.02	1.27	0.040	0.050
F	0.64	0.89	0.025	0.035
J	0.08	0.18	0.003	0.007
K	11.05	–	0.435	–
L	1.40	1.65	0.055	0.065
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
S	1.40	1.65	0.055	0.065
T	1.40	1.78	0.055	0.070
U	2.79	3.81	0.110	0.150
V	2.41	2.92	0.095	0.115

PACKAGE OUTLINE DIMENSIONS (continued)

CASE 305A-01

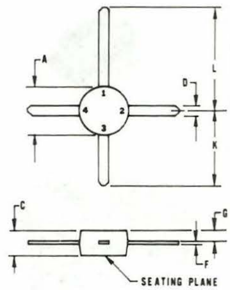




STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.08	5.59	0.200	0.220
C	2.41	3.30	0.095	0.130
D	1.40	1.65	0.055	0.065
E	1.02	1.27	0.040	0.050
F	0.64	0.89	0.025	0.035
J	0.08	0.18	0.003	0.007
K	11.05	–	0.435	–
M	45° NOM		45° NOM	

CASE 317-01

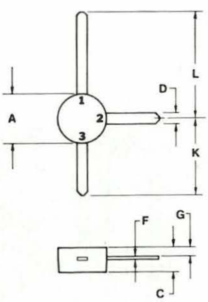


STYLE 1:
PIN 1. DRAIN
2. SOURCE
3. GATE 1
4. GATE 2

STYLE 2:
PIN 1. COLLECTOR
2. EMITTER
3. BASE
4. EMITTER

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.44	5.21	0.175	0.205
C	1.90	2.54	0.075	0.100
D	0.84	0.99	0.033	0.039
F	0.20	0.30	0.008	0.012
G	0.76	1.14	0.030	0.045
K	7.24	8.13	0.285	0.320
L	10.54	11.43	0.415	0.450

CASE 317A-01

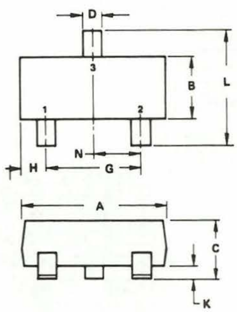


STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER

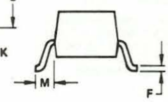
STYLE 2:
PIN 1. COLLECTOR
2. EMITTER
3. BASE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.44	5.21	0.175	0.205
C	1.90	2.54	0.075	0.100
D	0.94	0.99	0.033	0.039
F	0.20	0.30	0.008	0.012
G	0.76	1.14	0.030	0.045
K	7.24	8.13	0.285	0.320
L	10.54	11.43	0.415	0.450

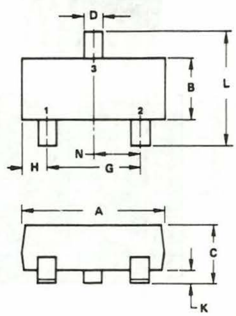
CASE 318 TO-236AA



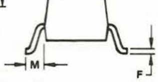
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.80	3.04	0.1102	0.1197
B	1.20	1.40	0.0472	0.0551
C	0.85	1.20	0.033	0.0472
D	0.37	0.46	0.015	0.0177
F	0.085	0.13	0.0034	0.0051
G	1.78	2.04	0.0701	0.0807
H	0.51	0.60	0.020	0.0236
K	0.10	0.25	0.004	0.0098
L	2.10	2.50	0.083	0.0984
M	0.45	0.60	0.018	0.0236
N	0.89	1.02	0.035	0.0401



CASE 318 TO-236AB



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.80	3.04	0.1102	0.1197
B	1.20	1.40	0.0472	0.0551
C	0.89	1.04	0.035	0.0412
D	0.37	0.46	0.015	0.0177
F	0.085	0.13	0.0034	0.0051
G	1.78	2.04	0.0701	0.0807
H	0.51	0.60	0.020	0.0236
K	0.013	0.10	0.0005	0.0040
L	2.10	2.50	0.083	0.0984
M	0.45	0.60	0.018	0.0236
N	0.89	1.02	0.035	0.0401



CASE 318 STYLES

STYLE 6:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

STYLE 7:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

STYLE 8:
PIN 1. ANODE
2. NO CONNECTION
3. CATHODE

STYLE 9:
PIN 1. ANODE
2. ANODE
3. CATHODE

STYLE 10:
PIN 1. DRAIN
2. SOURCE
3. GATE

STYLE 11:
PIN 1. ANODE
2. CATHODE
3. CATHODE ANODE

STYLE 12:
PIN 1. CATHODE
2. CATHODE
3. ANODE

STYLE 13:
PIN 1. SOURCE
2. DRAIN
3. GATE

STYLE 14:
PIN 1. CATHODE
2. GATE
3. ANODE

STYLE 15:
PIN 1. GATE
2. CATHODE
3. ANODE

STYLE 16.
PIN 1. ANODE
2. CATHODE
3. CATHODE

STYLE 17:
PIN 1. NO CONNECTION
2. ANODE
3. CATHODE

STYLE 18:
PIN 1. NC
PIN 2. CATHODE
PIN 3. ANODE

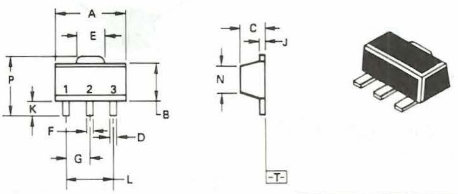
STYLES 1 THRU 5 ARE OBSOLETE.

NOTES
1. 318-02 MEETS ALL JEDEC DIMENSIONAL REQUIREMENTS FOR TO-236 AA.

8

PACKAGE OUTLINE DIMENSIONS (continued)

CASE 345-01



STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

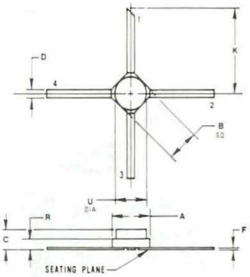
STYLE 2:
PIN 1. ANODE
2. CATHODE
3. NO CONNECTION

STYLE 3:
PIN 1. GATE
2. ANODE
3. CATHODE

STYLE 4:
PIN 1. DRAIN
2. GATE
3. SOURCE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.40	4.60	0.174	0.181
B	2.29	2.60	0.091	0.102
C	1.40	1.60	0.056	0.062
D	0.36	0.48	0.015	0.018
E	1.62	1.80	0.064	0.070
F	0.44	0.53	0.018	0.020
G	1.50 BSC		0.059 BSC	
J	0.35	0.44	0.014	0.017
K	0.80	1.04	0.032	0.040
L	3.00 BSC		0.118 BSC	
N	2.04	2.28	0.081	0.089
P	3.94	4.25	0.156	0.167

CASE 358-01

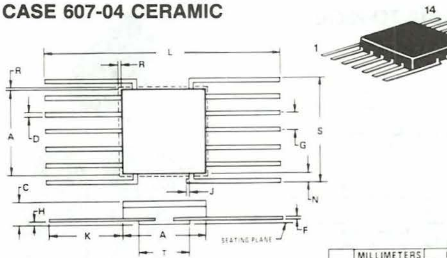


STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR
4. EMITTER

STYLE 2:
PIN 1. DRAIN
2. SOURCE
3. GATE 1
4. GATE 2

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	2.41	2.92	0.095	0.115
B	1.95	2.36	0.077	0.093
C	1.09	1.60	0.043	0.063
D	0.43	0.58	0.017	0.023
F	0.07	0.15	0.003	0.006
K	4.82	6.60	0.190	0.260
R	0.53	0.96	0.021	0.038
U	1.98	2.18	0.078	0.086

CASE 607-04 CERAMIC

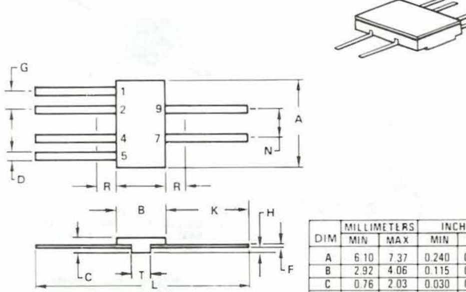


STYLE 1
BASE 2, 6, 9, 13
EMITTER 3, 5, 10, 12
COLLECTOR 1, 7, 8, 14

FOR COMPLEMENTARY QUADS
NPN PINS 1 THRU 3, 12 THRU 14
PNP PINS 5 THRU 7, 8 THRU 10
(REFER TO STYLE 1
FOR PIN IDENTIFICATION)

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	6.99	0.240	0.275
C	0.76	2.03	0.030	0.070
D	0.25	0.48	0.010	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	0.13	0.89	0.005	0.035
J	–	0.38	–	0.015
K	6.35	–	0.250	–
L	18.80	–	0.740	–
N	0.25	–	0.010	–
R	–	0.38	–	0.015
S	7.62	8.38	0.300	0.330
T	4.45	4.95	0.175	0.195

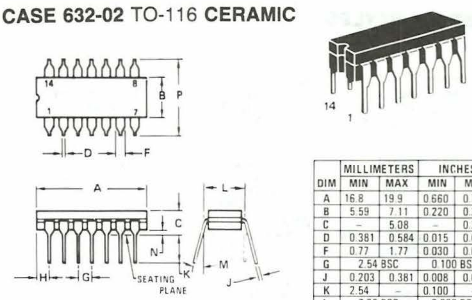
CASE 610A-04 CERAMIC



STYLE 1
BASE 1, 5
EMITTER 2, 4
COLLECTOR 9, 7
FOR COMPLEMENTARY PAIRS
NPN PINS 1, 2, 9
PNP PINS 4, 5, 7
(REFER TO STYLE 1 FOR PIN IDENTIFICATION)

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	7.37	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.070
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	0.13	0.89	0.005	0.035
K	3.81	–	0.150	–
L	10.54	–	0.415	–
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050
T	1.65	2.03	0.065	0.080

CASE 632-02 TO-116 CERAMIC



STYLE 1
COLLECTOR 1, 7, 8, 14
BASE 2, 6, 9, 13
EMITTER 3, 5, 10, 12

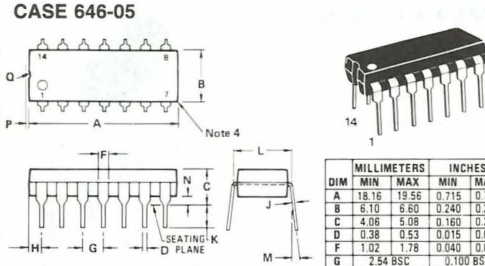
DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.8	19.9	0.660	0.785
B	5.59	7.11	0.220	0.280
C	–	5.08	–	0.200
D	0.381	0.584	0.015	0.023
F	0.77	1.77	0.030	0.070
G	2.54 BSC		0.100 BSC	
J	0.203	0.381	0.008	0.015
K	2.54	–	0.100	–
L	7.62 BSC		0.300 BSC	
M	–	15°	–	15°
N	0.51	0.76	0.020	0.030
P	–	8.25	–	0.325

COMPLEMENTARY PAIRS

TYPE 1	TYPE 2
NPN 1 THRU 3, 5 THRU 7	NPN 1 THRU 3, 12 THRU 14
PNP 8 THRU 10, 12 THRU 14	PNP 5 THRU 7, 8 THRU 10

(REFER TO STYLE 1 FOR PIN IDENTIFICATION)

CASE 646-05



STYLE 1
BASE 2, 6, 9, 13
EMITTER 3, 5, 10, 12
COLLECTOR 1, 7, 8, 14

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	18.16	19.56	0.715	0.770
B	6.10	6.60	0.240	0.260
C	4.06	5.08	0.160	0.200
D	0.38	0.53	0.015	0.021
F	1.02	1.78	0.040	0.070
G	2.54 BSC		0.100 BSC	
H	1.32	2.41	0.052	0.095
J	0.20	0.38	0.008	0.015
K	2.92	3.43	0.115	0.135
L	7.62 BSC		0.300 BSC	
M	0°	10°	0°	10°
N	0.51	1.02	0.020	0.040

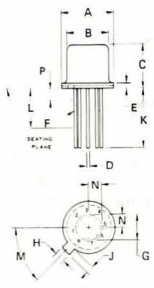
COMPLEMENTARY PAIRS

TYPE 1	TYPE 2
NPN 1 THRU 3, 5 THRU 7	NPN 1 THRU 3, 12 THRU 14
PNP 8 THRU 10, 12 THRU 14	PNP 5 THRU 7, 8 THRU 10

(REFER TO STYLE 1 FOR PIN IDENTIFICATION)

PACKAGE OUTLINE DIMENSIONS (continued)

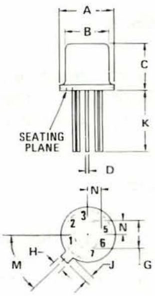
CASE 654-02



NOTES:
1. ALL RULES & NOTES ASSOCIATED WITH REFERENCED TO-78 (654-02) OUTLINE SHALL APPLY.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	4.19	4.70	0.165	0.185
D	0.41	0.53	0.016	0.021
E	–	1.02	–	0.040
F	0.41	0.48	0.016	0.019
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	2.54		0.100 BSC	
P	–	1.27	–	0.050

CASE 654-07



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654 STYLES

STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

STYLE 2:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. SOURCE
6. DRAIN
7. GATE
8. OMITTED

STYLE 3:
PIN 1. EMITTER
2. BASE
3. COLLECTOR
4. OMITTED
5. ANODE
6. NO CONNECTION
7. CATHODE
8. OMITTED

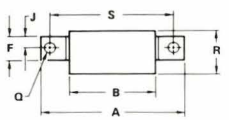
STYLE 4:
PIN 1. GATE
2. SOURCE
3. DRAIN
4. OMITTED
5. DRAIN
6. SOURCE
7. GATE
8. OMITTED

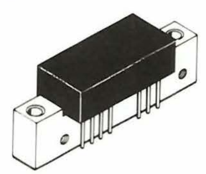
STYLE 5:
SIDE 1 (NPN)
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
SIDE 2 (PNP)
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

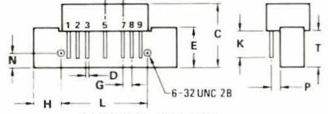
STYLE 6:
PIN 1. SOURCE
2. DRAIN
3. GATE
4. OMITTED
5. SOURCE
6. DRAIN
7. GATE
8. OMITTED

8

CASE 714-02







FIRST STAGE: PIN 1, RF IN
4, RF OUT

SECOND STAGE: PIN 6, RF IN
9, RF OUT

Vdc: PIN 5

DC AND RF GROUND: PINS 2, 3, 7, 8

NOTE
1. MOUNTING HOLES WITHIN 0.25 mm (0.010) DIA OF TRUE POSITION AT MAXIMUM MATERIAL CONDITION

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	45.08	–	1.775
B	26.42	26.92	1.040	1.060
C	20.57	21.34	0.810	0.840
D	0.46	0.56	0.018	0.022
E	11.81	12.95	0.465	0.510
F	7.62	8.13	0.300	0.320
G	2.41	2.67	0.095	0.105
H	9.65	9.78	0.380	0.385
J	3.96 BSC		0.156 BSC	
K	6.86	7.37	0.270	0.290
L	25.40 BSC		1.000 BSC	
N	4.06	4.32	0.160	0.170
P	2.16	2.92	0.085	0.115
Q	3.76	4.27	0.148	0.168
R	–	15.11	–	0.595
S	38.10 BSC		1.500 BSC	
T	11.05	11.43	0.435	0.450
U	4.95	5.21	0.195	0.205

Application Note Abstracts

(Application Notes are available upon request.)

AN-139A Understanding Transistor Response Parameters

This note explains high-frequency transistor response parameters and discusses their interdependence. Useful nomograms are given for determining h_{fe}, f_T, $f_{\alpha e}$, f_{max}, and many other parameters.

AN-211A Field-Effect Transistors in Theory and Practice

The basic theory, construction, and application information for field-effect transistors (junction and MOS types) are given. Also included are some typical test circuits for checking FET parameters.

AN-215A RF Small-Signal Design Using 2-Port Parameters

Power gain and stability of high-frequency transistors may be completely described by two port parameters.

This paper presents a summary of the overall design solution for the small-signal RF amplifier using two-port parameters. Design considerations and relationships for both the stable and the potentially unstable transistor are presented together with a discussion of neutralized, unneutralized, matched, and mismatched amplifiers.

AN-267 Matching Network Designs with Computer Solutions

Computer solutions for four networks commonly used in solid-state high frequency amplifiers have been tabulated.

AN-268 Pulse Triggering of Radar Modulator SCR's

8

Factors involved in dynamic gate triggering are examined and relations of gate triggering characteristics to variations of total current amplifications with gate current are shown.

AN-270 Nanosecond Pulse Handling Techniques in IC Interconnections

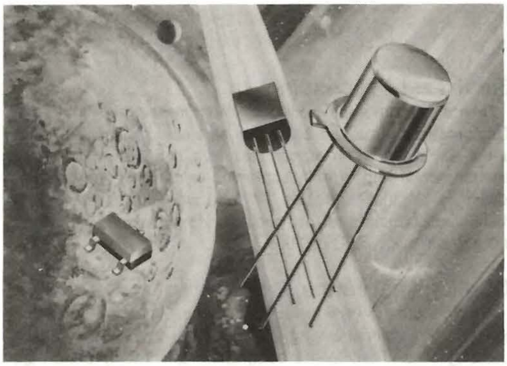
The rapid advancement in the field of high speed digital integrated circuits has brought into focus many problem areas in the methods of pulse measurement techniques and new concepts dealing with these problems. This paper is intended to discuss the more common, yet perhaps not well

AN-421 Semiconductor Noise Figure Considerations

A summary of many of the important noise figure considerations related with the design of low noise amplifiers is presented. The basic fundamentals involving noise, noise figure, and noise figure-frequency characteristics are then discussed with the emphasis on characteristics common to all semiconductors. A brief introduction is made to various methods of data sheet presentation of noise figure and a summary is given for the various methods of measurement. A discussion of low noise circuit design, utilizing many of the previously discussed considerations, is included.

EN-101 Verifying Collector Voltage Ratings

Methods of verifying the various voltage ratings given on transistor data sheets are described. Practical test circuits are given and testing problems are discussed. A detailed discussion of the avalanche breakdown mechanism and the significance of various voltage ratings is also included.



Discrete products are available from Motorola in three quality levels: Industrial/Commercial grade, Military grade, and Customer Specials.

This Reliability and Quality Assurance section contains information on final test and quality assurance processing. Included is a listing of Q.A. tests and the applicable MIL-STD methods relating to the above-noted quality levels.

High reliability (JAN, JANTX, JANTXV, and JANS) processing of transistors is outlined by using a processing and quality control flow chart.

A glossary of Reliability and Quality terms is also included.

Reliability and Quality Assurance

9

Reliability and Quality Assurance

Quality Levels

Most small-signal discrete products are available from Motorola in three quality levels:

1. INDUSTRIAL/COMMERCIAL GRADE — Identified by a part number prefix such as 2N, MM or MPS and tested to a published Motorola, JEDEC or Proelectron specification.
2. MILITARY GRADE — Identified by a 2N part number prefix, a JAN, JTX, JTXV or JANS suffix, and manufactured and tested per MIL-S-19500.
   - JAN — Controlled lot with sample environmental and life testing
   - JTX — Same as JAN plus 100% processing
   - JTXV — Same as JTX plus 100% internal visual inspection
   - JANS — Same as JTXV plus wafer lot acceptance and additional 100% processing requirements.
3. CUSTOMER SPECIAL — Screening, testing and marking as determined by the customer to meet his particular requirements. This may range from a custom-marked industrial/commercial grade product to a hi-rel product which is subjected to a series of stringent inspections and tests to meet aerospace or special military requirements.

Final Test Processing

Device lots are subjected to 100% processing in Final Test. This processing may be as simple as electrical testing to data sheet specifications or as complex as a series of mechanical, environmental and burn-in screening tests preceded and followed by electrical readouts. All lots, whether industrial/commercial, military or hi-rel, are subjected to a minimum eight-hour storage bake at 150°C or 200°C.

Quality Assurance Processing

All products are transferred to QA where they are subjected to Group A electrical testing, usually to the same specifications used by Final Test. In the past, QA has primarily performed sample testing; but now, at Motorola, most small-signal metal can transistors are 100% electrical tested by QA, and when this expansion program is completed, all small-signal transistors will be subjected to 100% QA electrical testing. Military and hi-rel lots may undergo additional 100% screening in QA. Using the popular 2N2222A family as an example, Table 1 compares the varying degrees of preconditioning and screening that are done on the 2N2222A, 2N2222AJAN, 2N2222AJTX, 2N2222AJTXV and 2N2222AJANS transistors. QA randomly selects test samples for Group A, B and C testing as defined in MIL-S-19500. The individual tests are defined in MIL-STD-750. Tables 2 and 3 list the Group B and C test requirements for the 2N2222A military family.

TABLE 1 — 100% PRECONDITIONING AND SCREENING (2N2222A Family)

Test	MIL-STD-750 Method	Condition	2N2222A 2N2222AJAN	2N2222AJTX 2N2222AJTXV	2N2222AJANS
1. Electrical tests	—	go – no go	100%	100%	100%
2. High temperature storage	1032	200°C, 24 hours	—	100%	100%
3. Thermal shock	1051	C, 20 cycles	—	100%	100%
4. Constant acceleration	2006	20,000 G, Y1	—	100%	100%
5. Particle impact noise	2052	B	—	—	100%
6. Hermetic seal					
fine leak	1071	G or H	—	100%	100%
gross leak	1071	A, C, E or F	—	100%	100%
7. Electrical tests	—	read & record	—	—	100%
8. H.T. reverse bias	1039	150°C, 48 hours	—	100%	100%
9. Electrical tests	—	read & record*	—	100%	100%
10. Full-power burn-in	1039	25°C, 168 hours	—	100%	—
11. Full-power burn-in	1039	25°C, 240 hours	—	—	100%
12. Electrical tests	—	read & record*	—	100%	100%
13. Hermetic seal					
fine leak	1071	G or H	—	100%	100%
gross leak	1071	A, C, E or F	—	100%	100%
14. X-ray	2076	—	—	—	100%
15. External visual	2071	—	—	—	100%

*Bin & cell may be used for JTX and JTXV product

9

TABLE 2 — GROUP B TESTS (2N2222AJAN/JTX/JTXV/JANS)

Inspection or Test	MIL-STD-750 Method	Condition	LTPD (Accept No.) and Military Classification
SUBGROUP LTPD			10 (0)
1. Physical dimensions	2066	—	JANS
SUBGROUP LTPD			15(1)
2. Solderability	2026	—	ALL
3. Solvent resistance	1022	—	ALL
SUBGROUP LTPD			10 (1)
4. Thermal shock	1051	C1, 25 cycles	JAN, JTX, JTXV
Thermal shock	1051	C3, 100 cycles	JANS
5. Hermetic seal			
fine leak	1071	G or H	ALL
gross leak	1071	A, C, E or F	ALL
6. Decap internal visual	2075	—	JANS
7. Bond strength	2037	A	JANS
8. Die shear	2017	—	JANS
SUBGROUP LTPD			5 (2)
9. Operating life	1027	25°C, 340 hours	JAN, JTX, JTXV
SUBGROUP LTPD			20 (0)
10. Decap internal visual	2075	—	JAN, JTX, JTXV
11. Bond strength	2037	A	JAN, JTX, JTXV
SUBGROUP LTPD			10 (2)
12. Intermittent operating life	1037	25°C, 2000 cycles	JANS
SUBGROUP LTPD			10 (2)
13. Accelerated operating life	1027	125°C, 96 hours	JANS
SUBGROUP LTPD			7 (2)
14. High-temperature storage life	1032	200°C, 340 hours	JAN, JTX, JTXV

TABLE 3 — GROUP C TESTS (2N2222AJAN/JTX/JTXV/JANS)

Inspection or Test	MIL-STD-750 Method	Condition	LTPD (Accept No.) and Military Classification
SUPGROUP LTPD			15 (1)
1. Physical dimensions	2066	—	ALL
SUBGROUP LTPD			10 (1)
2. Thermal shock	1056	A	ALL
3. Terminal strength	2036	E	ALL
4. Hermetic seal			
fine leak	1071	G or H	ALL
gross leak	1071	A, C, E or F	ALL
5. Moisture resistance	1021	Omit initial precond.	ALL
6. External visual	2071	—	ALL
SUBGROUP LTPD			10 (1)
7. Shock	2016	1500G	ALL
8. Variable-frequency vibration	2056	100–2000 Hz	ALL
9. Constant acceleration	2006	20,000 G	ALL
SUBGROUP LTPD			15 (1)
10. Salt atmosphere	1041	—	ALL
SUBGROUP LTPD			10 (1)
11. Operating life	1026	25°C, 1000 hours	ALL

9

High Reliability Processing of Transistors

I WAFER PROCESSING

After wafers are processed, they are subjected to Motorola visual inspection requirements and overlay geometry wafers are subjected to a sample SEM inspection to assure good step coverage. The wafers are then probed to electrical requirements and the rejects are inked. Finally, they are sawn and separated to form the individual dice.

II ASSEMBLY

The die are attached to headers and then wire bonded. The following mechanical tests are performed by Quality Control inspectors on a sample basis to ensure assembly process controls.

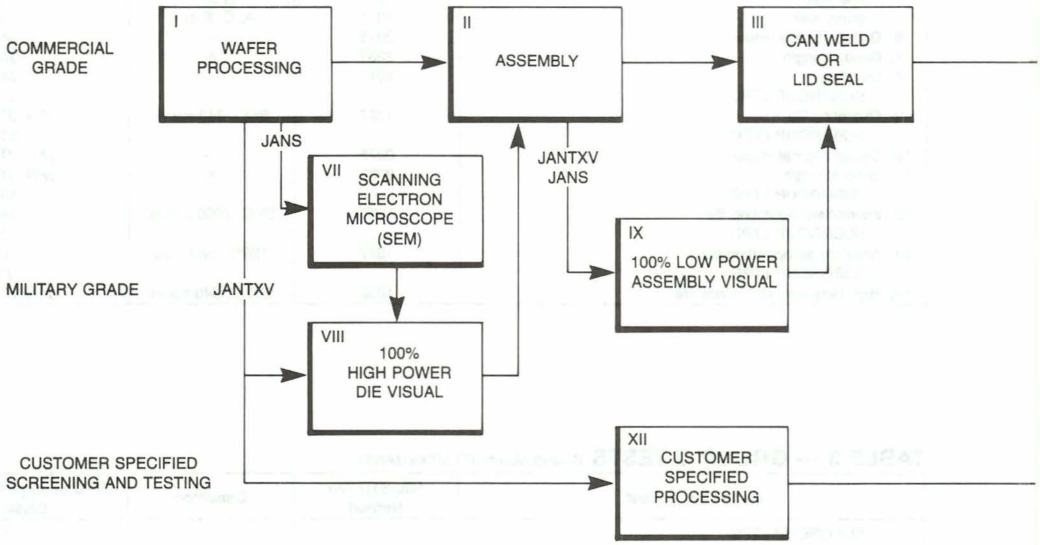
(1) Wire pull tests
(2) Die push off tests

Units are stored in dry air until ready for capping.

III CAN WELD OR LID SEAL

Completed headers are loaded into a vacuum chamber for can weld or processed thru a furnace for top attachments on ceramic packages. All devices are subjected to a high temperature storage (stabilization bake) prior to final electrical test.

PROCESSING AND QUALITY CONTROL FLOW CHART



VII SCANNING ELECTRON MICROSCOPE

All JANS product with overlay geometry requires a SEM inspection per MIL-STD-750, method 2077. To assure good metallization step coverage, Motorola monitors all overlay geometry transistor wafer lines whether or not it is required.

XII CUSTOMER SPECIFIED PROCESSING

Screening, testing and marking as determined by the customer to meet his particular requirements, which may range from a custom-marked standard product to a hi-rel product that is subjected to the most stringent tests for aerospace or military applications.

VIII 100% HIGH POWER DIE VISUAL

The high power portion of the inspection is performed to assure good die construction and front metal conditions. Individual reject criteria includes the following: Metallization defects such as scratches, voids, corrosion, adherence, bridging and alignment. Poor die construction conditions such as oxide and faults are also rejected.

IX 100% LOW POWER ASSEMBLY VISUAL

The low power visual inspection controls workmanship, i.e., die attachment, internal lead-wire attachment, and package defects. Die attachment inspection includes assuring good watting, die placement and proper orientation. Internal lead wires must have proper arc and all attachment bonds must be properly placed and in good condition. Package defect inspection includes checking for foreign material, improper construction and cracked feedthroughs.

9

IV 100% FINAL ELECTRICAL TEST

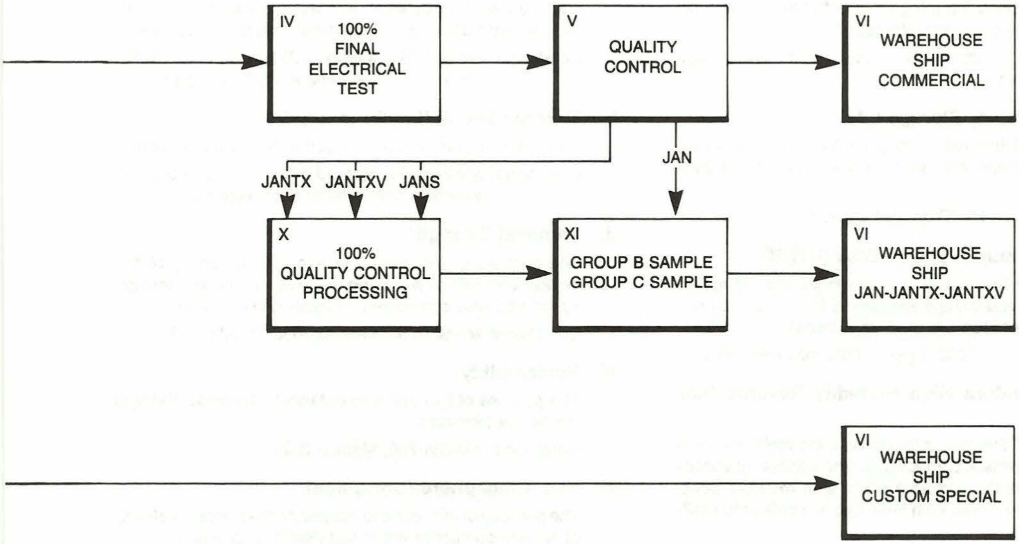
Completed devices are subjected to 100% testing to electrical requirements. When different devices are sourced from a single product line, they are sorted for voltage and gain.

V QUALITY CONTROL

Although it has been traditional for QA to perform sample testing, today most small-signal metal can transistors are 100% electrical tested by QA. Soon, all transistors will be 100% tested by QA. Group A and B tests are performed on JAN devices. Group A and B tests and 100% processing are performed on JANTX, JANTXV and JANS devices. Group C testing is required on a periodic basis.

VI WAREHOUSE

Upon completion, the finished product is ready for shipping. Purchase order requirements are carefully checked again prior to shipping. Warranty tests (Group A) are performed every 24 months on military devices.



X 100% QUALITY CONTROL PROCESSING

a. High-temperature storage
b. Thermal shock
c. Constant acceleration
d. Particle impact noise (JANS)
e. Hermetic seal
f. High-temperature reverse bias
g. Full-power burn-in
h. X-ray (JANS)
i. External visual (JANS)
j. Read and record parameters

XI GROUP B AND GROUP C INSPECTION

Typical Group B Processing	Typical Group C Processing
a. Physical dimensions	a. Physical dimensions
b. Solderability	b. Thermal shock
c. Solvent resistance	c. Terminal strength
d. Thermal shock	d. Hermetic seal
e. Hermetic seal	e. Moisture resistance
f. Decap internal visual	f. External visual
g. Bond strength	g. Shock
h. Die shear	h. Variable-frequency vibration
i. 340 hr. operating life	i. Constant acceleration
j. Intermittent operating life (JANS)	j. Salt atmosphere
k. Accelerated operating life (JANS)	k. 1000 hr. operating life
l. 340 hr. storage life	

9

Test Descriptions

The following tests are frequently used for screening, acceptance and evaluation of semiconductor devices.

A. Steady State Operating Life (SSOL)

The purpose of this test is to evaluate the bulk stability of the die and to generate defects resulting from manufacturing aberrations that are manifested as time and stress-dependent failures.

Conditions: T_A = 25°C, PD = max rated power

B. Intermittent Operating Life (IOL)

The purpose of this test is the same as Operating Life in addition to checking the integrity of both the wire and die bonds by means of thermal stressing.

Conditions: T_A = 25°C, PD = max rated power. $T_{(on)}$ = $T_{(off)}$ = 1 min.

C. High Temperature Storage Life

The purpose of this test is to generate time/temperature failure mechanisms and to evaluate long-term storage stability.

Conditions: T_A = 150°C no bias applied

D. High Temperature Reverse Bias (HTRB)

The purpose of this test is to align mobile ions by means of temperature and voltage stresses to form a high-current leakage path between two or more terminals.

Conditions: T_A = 150°C, V_{CB} = 80% max rated V_{CB}.

E. High Temperature High Humidity Reverse Bias (H^3TRB)

The purpose of this test is to evaluate the moisture resistance of non-hermetic components. The addition of voltage bias accelerates the corrosive effect after moisture penetration has taken place. With time, this is a catastrophically destructive test.

Conditions: T_A = 85°C, RH = 85%, V_{CB} = 80% max rated V_{CB}.

F. Moisture Resistance

The purpose of this test is to evaluate the moisture resistance of components under temperature/humidity conditions typical of tropical environments.

Conditions: Mil-Std-750, Method 1021.

G. Pressure Cooker

The purpose of this test is to evaluate the moisture resistance of non-hermetic components under pressure/temperature conditions.

Conditions: T = 121°C, P = 1 atmosphere (15 psig)

H. Temperature Cycle (Air to Air)

The purpose of this test is to evaluate the ability of the device to withstand both exposure to extreme temperatures and the transition between temperature extremes, and to expose excessive thermal mismatch between materials.

Conditions: Mil-Std-750, Method 1051, −55°C to 150°C, 15 minutes dwell time at each temperature

I. Thermal Shock (Liquid to Liquid)

This test is an accelerated version of temperature cycle.

Conditions: Mil-Std-750, Method 1056, 0°C to 100°C, 15 seconds dwell time at each temperature

J. Terminal Strength

The purpose of this test is to evaluate the ability of the device terminals to withstand the lead forming and tension associated with component installation into a circuit.

Conditions: Mil-Std-750, Method 2036, Condition E.

K. Solderability

The purpose of this test is to determine the solderability of the device terminals.

Conditions: Mil-Std-750, Method 2026.

L. Salt Atmosphere (Corrosion)

The purpose of this test is to accelerate the corrosion effects of an environment in which salt (NaC1) is present.

Conditions: Mil-Std-750, Method 1041

M. Mechanical Stress Tests

Vibration, shock and constant acceleration tests are infrequently used since they rarely generate failures in small-signal transistors. However, they are still specified for acceptance of military product.

Glossary of Reliability and Quality Terms

Acceptable Quality Level (AQL) — A measure of quality for which a given lot will be accepted most of the time. This is usually established at a probability of acceptance equal to 95%. It is referred to as the producer's risk because the probability of rejecting a good lot is 5%.

Acceptance Number (Ac) — The largest number of defectives in an inspection sample under consideration that will permit acceptance of the lot.

Acceptance Tests — Tests to determine conformance to specification requirements as a basis for lot acceptance.

Average Outgoing Quality (AOQ) — The average quality of outgoing product after 100% screening of rejected lots. This is usually measured in parts per million (PPM).

Average Outgoing Quality Limit (AOQL) — The maximum average outgoing quality that is possible for a given sampling plan.

Defect — Any deviation of a device that does not conform to specified requirements. One device may contain more than one defect.

Defective — A device which contains one or more defects.

Double Sampling — Sampling inspection in which the inspection of the first sample leads to a decision to accept, to reject, or to take a second sample. The inspection of a second sample, when required, always leads to a decision to accept or to reject.

Failure — The inability of a device to perform a specified function within previously-established limits.

Failure Rate — The statistical probability of a failure occurring within a stated period of time. For electronic components it is usually assumed that failures follow an exponential distribution, in which case the failure rate over any stated period of time is constant. The failure rate of semiconductor devices is generally given in percent per thousand hours.

Infant Mortality — Premature failures occurring at a failure rate substantially greater than that observed during subsequent life prior to wear-out.

Lot — A group of devices from which samples are drawn and inspected to determine compliance with acceptance criteria (inspection lot).

Lot Tolerance Percent Defective (LTPD) — A measure of quality for which a given lot will be rejected most of the time. This is usually established at a probability of acceptance equal to 10%. It is referred to as the consumer's risk because the probability of accepting a bad lot is 10%.

Mean Time Between Failures (MTBF) — The total measured operating time of a group of equipments divided by the total number of failures of a repairable equipment. In the case of an exponential failure distribution, this ratio is the reciprocal of failure rate.

Operating Characteristic Curve (OC curve) — A graph of the probability of acceptance as a function of the lot quality or process average quality, whichever is applicable.

Percent Defective — The number of defective devices in a lot divided by the total number of devices in that lot, multiplied by 100.

Probability of Acceptance (Pa) — The fractional probability that a lot will be accepted, usually expressed as a decimal.

Process Average Quality — The expected quality of product from a given process, usually estimated from first sample results of previous inspection lots.

Quality — A measure of the degree to which a product conforms to specification and workmanship requirements.

Rejection Number (Re) — The smallest number of defectives in an inspection sample under consideration that will prevent acceptance of the lot.

Reliability — A measure of the performance of a product over a specified period of time.

Sample — One or more devices selected at random from an inspection lot to represent that lot for acceptance purposes.

Sampling Plan — A specific plan which defines the sample size and the criteria for accepting or rejecting a lot.

Screening Tests — Tests employing nondestructive environmental, electrical, thermal and/or mechanical stresses, for the purpose of identifying anomalous devices.

Single Sampling — Sampling inspection in which a decision to accept or to reject is reached after the inspection of a single sample.

Wearout Failures — Those failures which occur as a result of deterioration processes and whose probability of occurrence increases with time.

100% Inspection — Inspection of every device, in which each device is accepted or rejected individually for the characteristic concerned, on the basis of its own inspection only.

MOTOROLA Semiconductor Products Inc.
BOX 20912 • PHOENIX, ARIZONA 85036 • A SUBSIDIARY OF MOTOROLA INC.